Stato e richieste degli esperimenti di Gruppo III Padova

Daniele Mengoni

https://www.pd.infn.it/it/gruppo3-fisicanucleare/

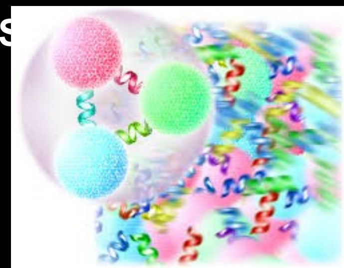
Daniele Mengoni – DFA/INFN Pd
Consiglio di Sezione INFN
Padova, 03 Luglio 2025

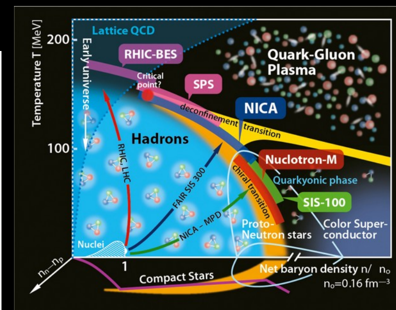
Dipartimento di Fisica e Astronomia Galileo Galilei

INFN PADOVA
Istituto Nazionale di Fisica Nucleare
Sezione di Padova

6 research lines: 26 exps

1.**QUARKS AND HADRON DYNAMICS**
ePIC (BNL) , JLAB12 (JLAB), KAONNIS (LNF) MAMBO (Mainz-Bonn), ULYSSES (JPARC)



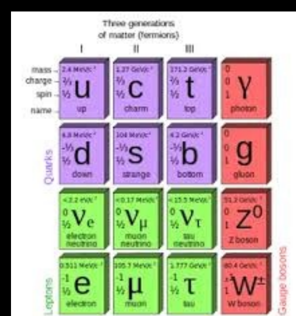


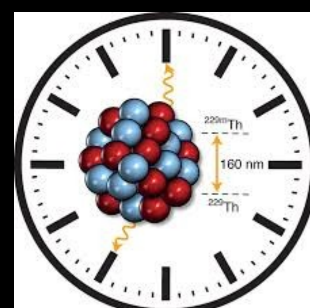
2.**PHASE TRANSITION IN HADRONIC MATTER:**
ALICE (CERN), NA60+(CERN)

3.**NUCLEAR STRUCTURE AND REACTION MECHANISM:**
~~**EXOTIC**~~**,** FORTE, **GAMMA,** NEWCHIM, **NUCL-EX(DTZ)**~~,~~ NUMEN_GR3, **PRISMA_FIDES (LNS, LNL, GANIL, RIKEN....)**

4 .**NUCLEAR ASTROPHYSICS:**
ASFIN2, ERNA, **LUNA (LNGS) ,** n_TOF, **PANDORA** (LNS, LNL, LNGS, CIRCE , CERN...)

5.**FUNDAMENTAL INTERACTIONS:**
~~ASACUSA (CERN),~~ ~~**AEgIS**~~ (CERN), LEA (CERN), JEDI (Bonn),VIP (LNGS), FAMU (RAL)

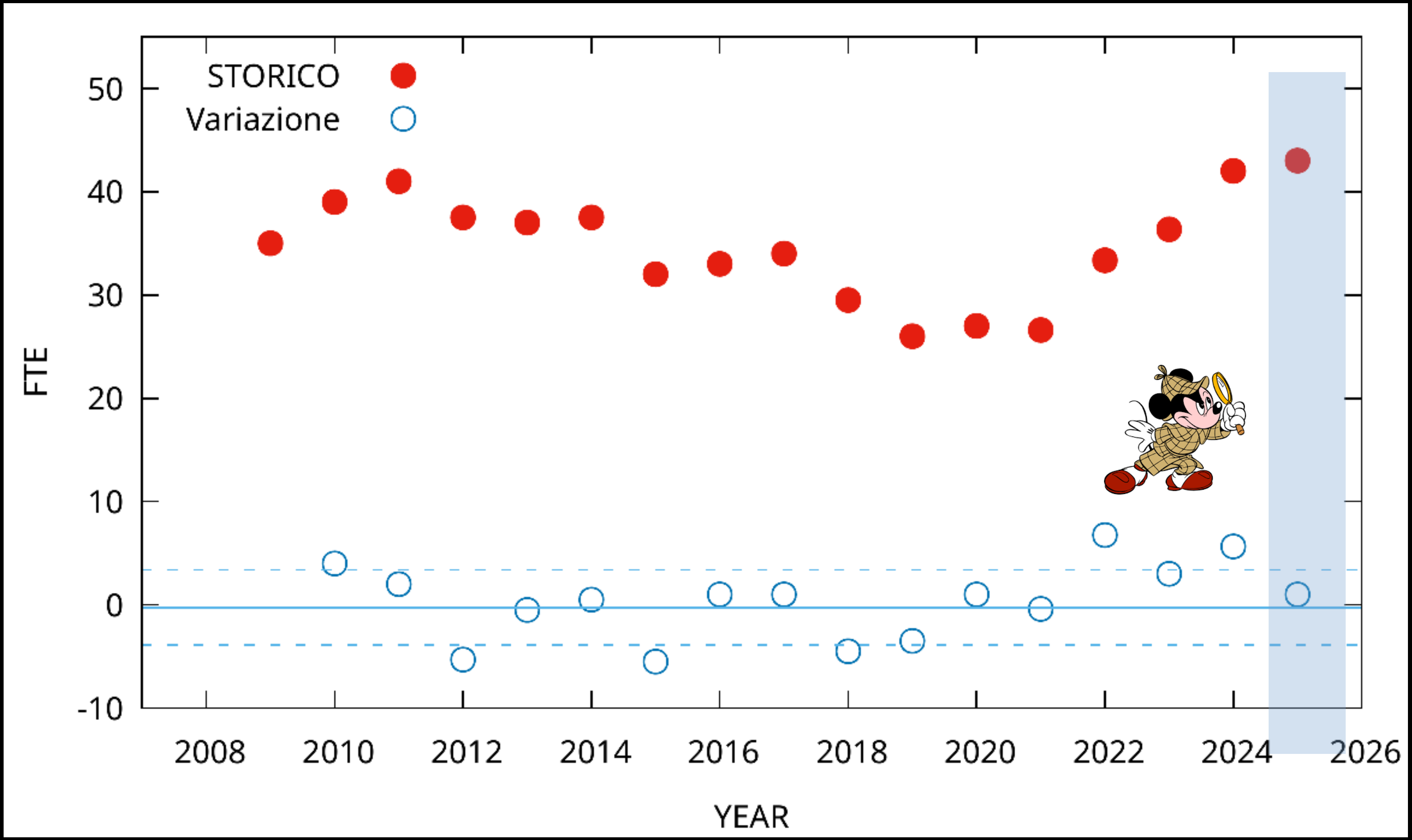




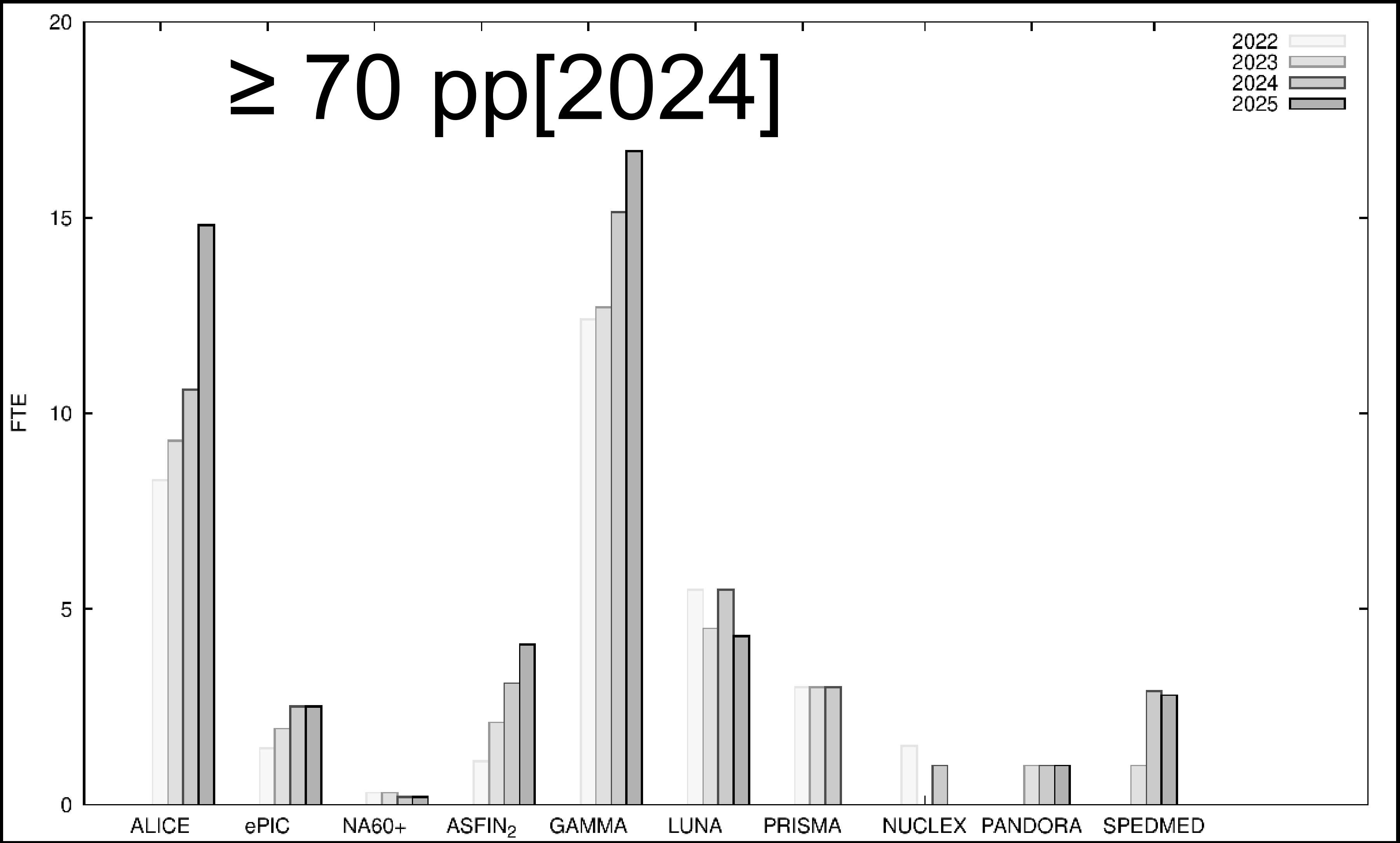
6.**APPLICATIONS AND SOCIETAL BENEFITS:**
TORIO (GE), FOOT (GSI,CNAO,TIFPA), **SPES_MED**

CSN3 National/International activity

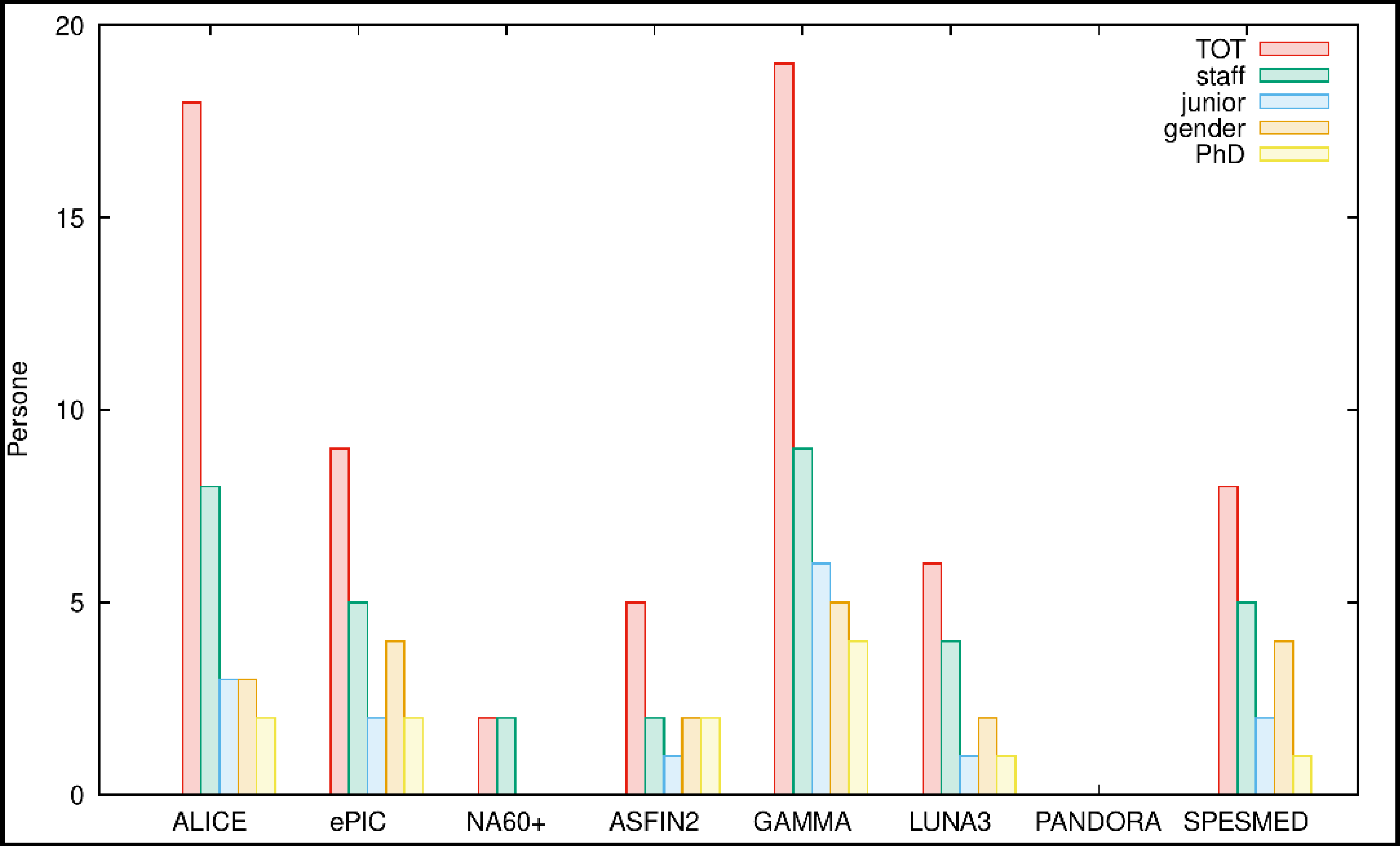
STORICO (da validare entro 24/06)



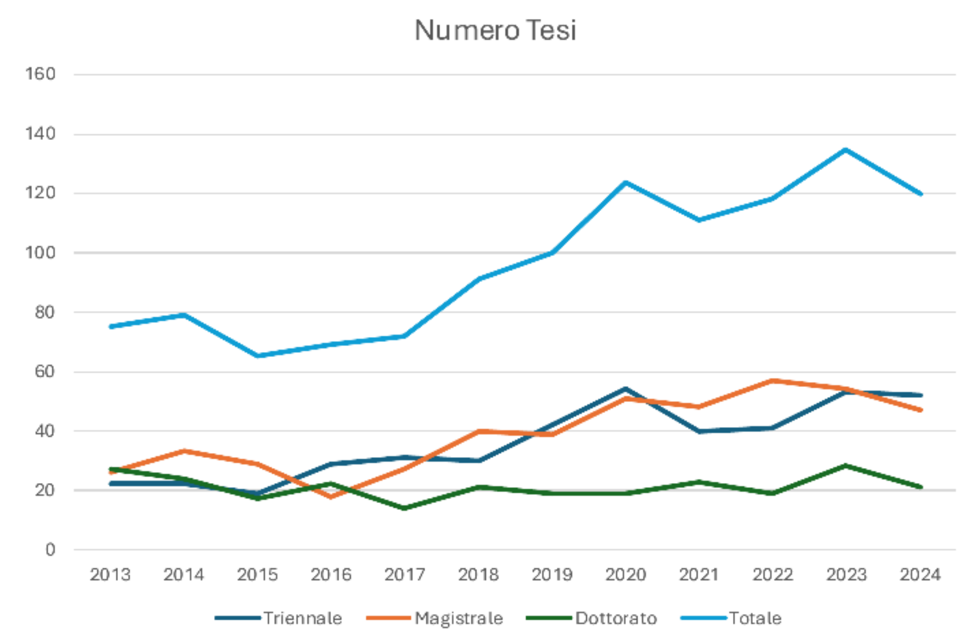
Stat (43 FTE, ~1 FTE wrt 2024)

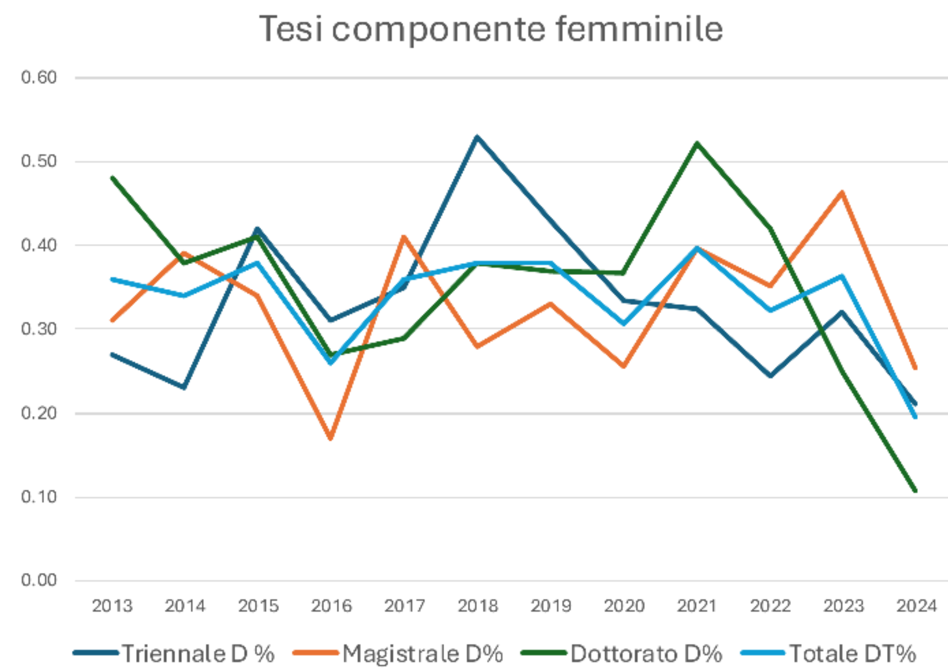


Composizione dei gruppi

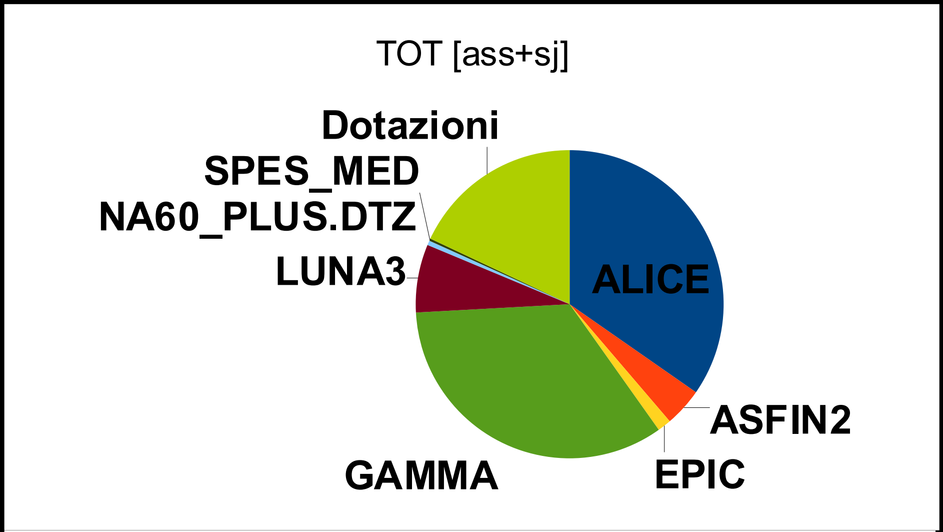


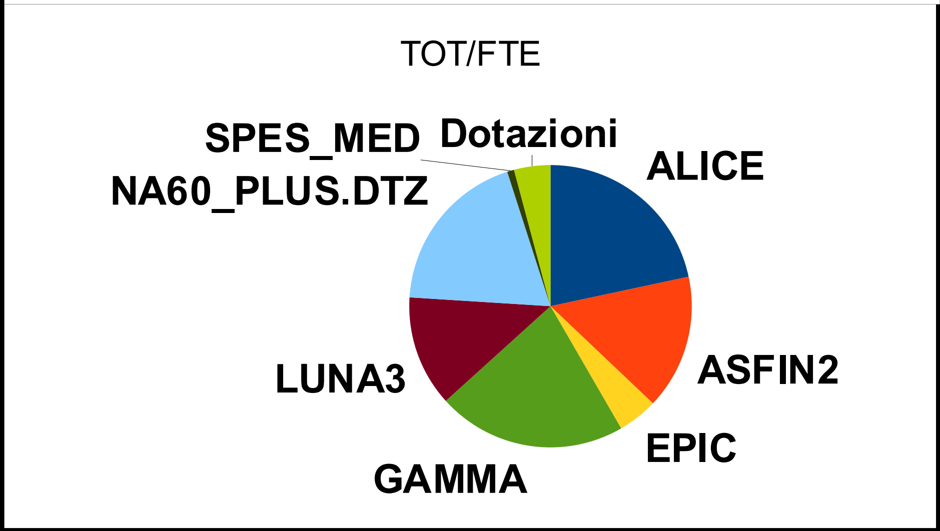
GLV_24 CSN3 da consolidare





Fondi





~500 kE/Y (~5% budget CSN3)

[2025]~70 pp, ~46 FTE

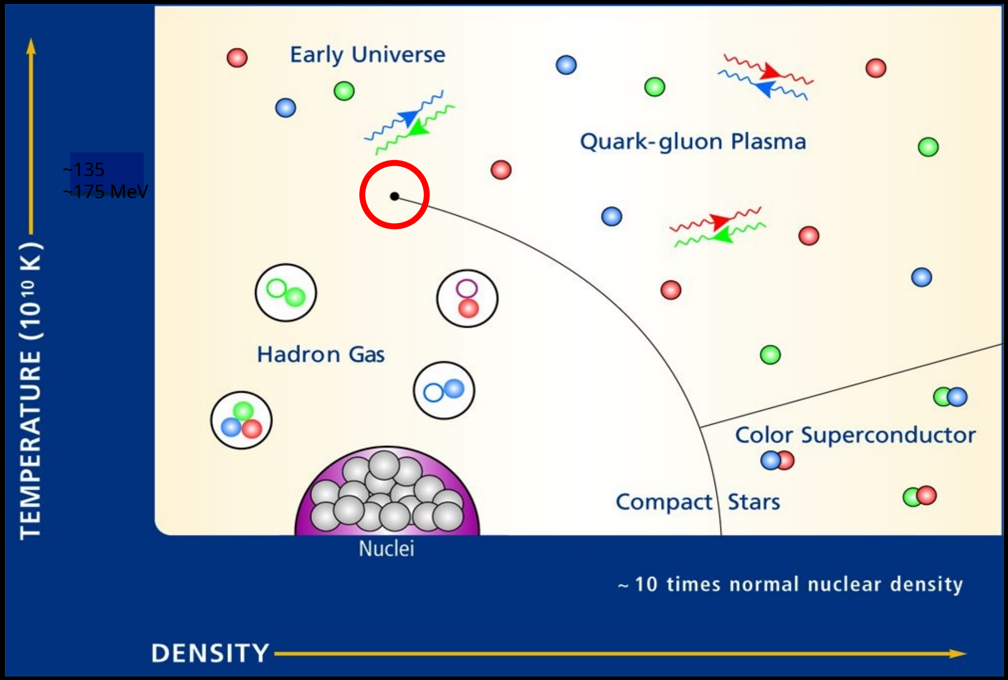
→ ~7 kE/PP

75% sono incaricati/associati INFN

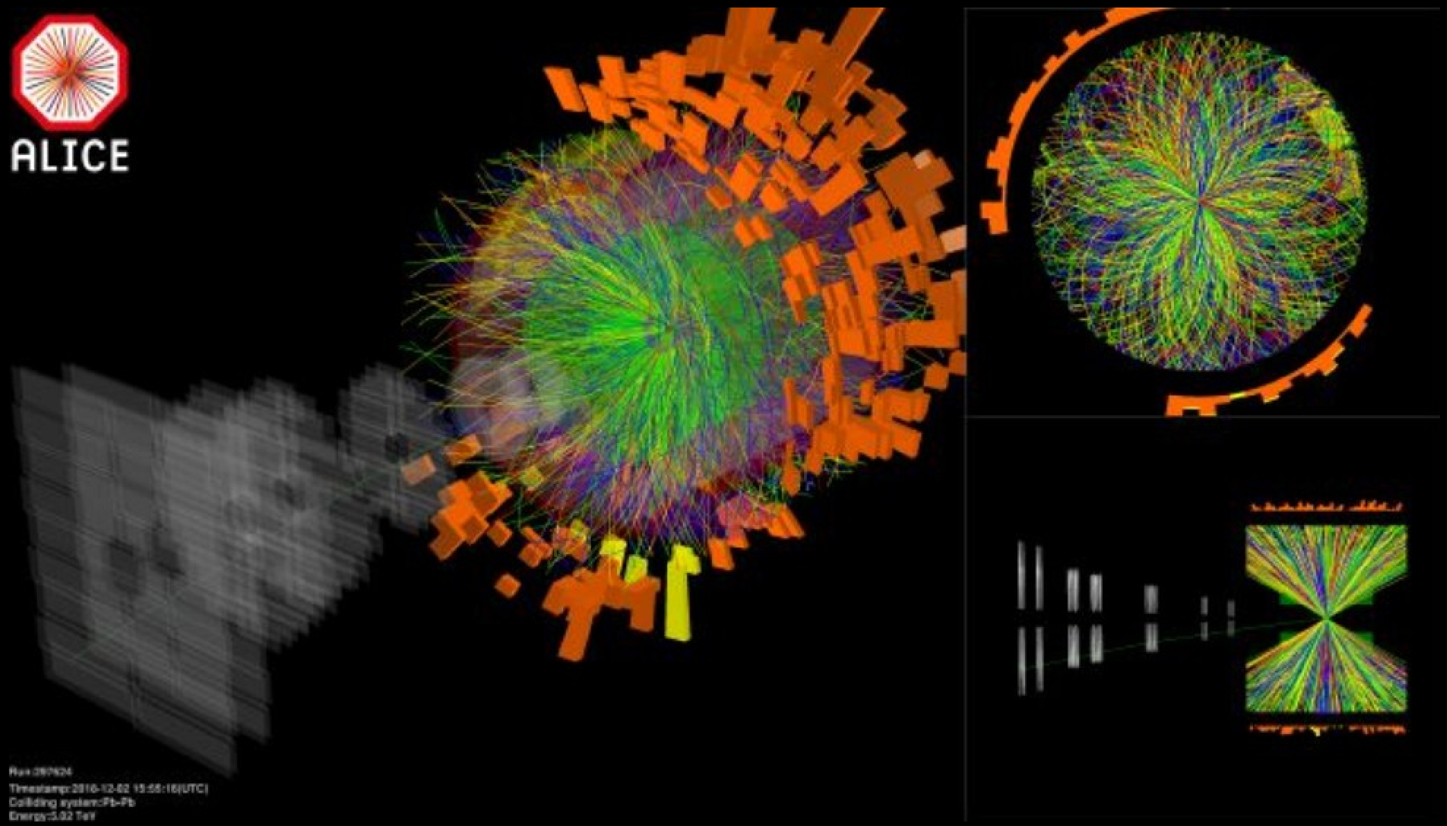
+Common funds (MoFAB etc/MoU): ~100 kE ALICE e ~100 kE AGATA (già scalati su PD)

1 Quarks and hadron dynamics

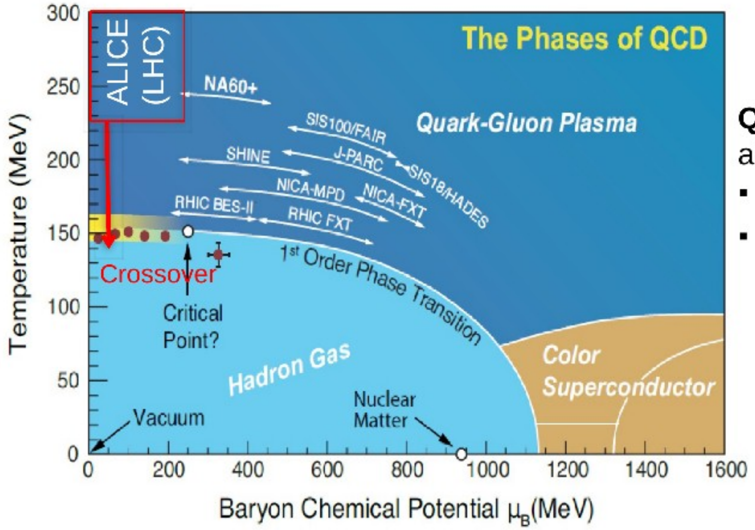
2 Phase transitions of nuclear and hadronic matter



ALICE



Introduzione

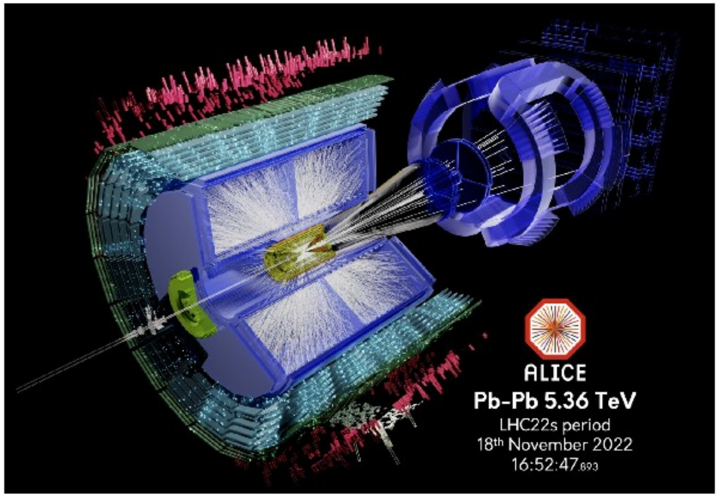


Quark-Gluon Plasma: stato della materia adronica ad alta densità di energia, in cui viene meno il confinamento.

- Sistema “macroscopico” di quark e gluoni interagenti
- Accesso a proprietà fondamentali QCD: confinamento, meccanismi di interazione, origine “dinamica” massa quark costituenti e particelle.

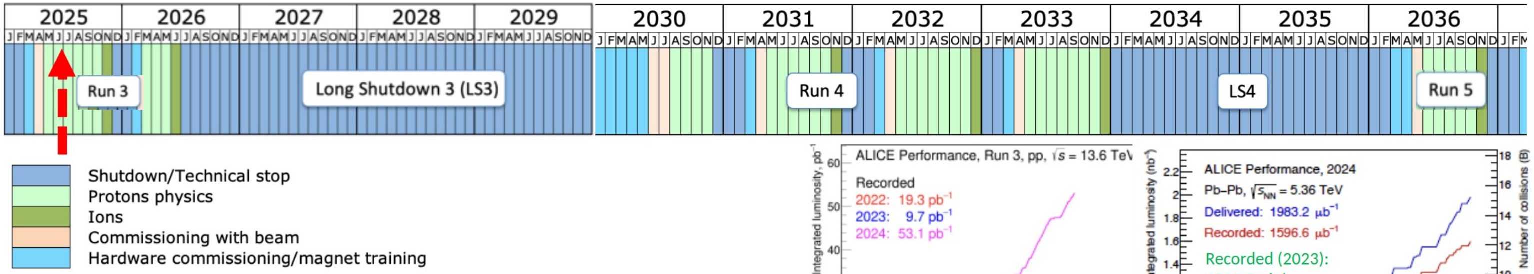
Focus del gruppo ALICE-Padova: studio del QGP attraverso gli effetti che manifesta sui **quark pesanti (c e b),** prodotti all’inizio della collisione

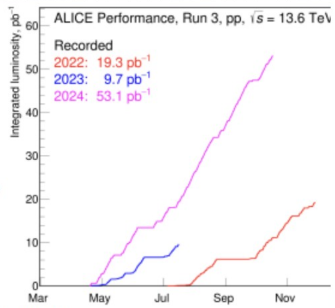
- attraversano tutte le fasi del sistema e sono chiaramente identificabili nello stato finale
- Ruolo centrale rivelatori “di vertice” a **pixel di silicio → SPD, ITS upgrades, ALICE3**

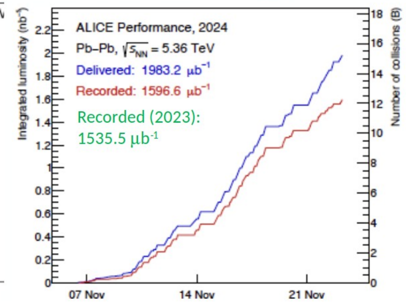


Event display pilot beam Pb-Pb 5.36 TeV, novembre 2022

Attività ultimo anno e status attuale



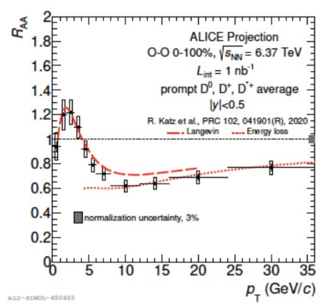


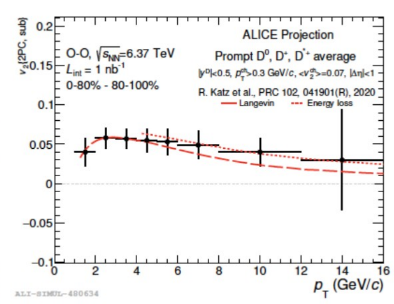


1 y alla fine del Run 3, avvenuto dopo upgrade sostanziale
Data-taking in continuous (triggerless) readout
Guadagno in statistica ~x2000 (pp) x25 (Pb-Pb) (finora)
per la maggior parte delle osservabili
2024: pp 13.6 TeV + **run pp (5.3 pb^{-1}) e Pb-Pb a 5.36 TeV (1.5 nb^{-1})**
2025: pp 13.6 TeV (in corso), Pb-Pb 5.36 TeV (2.6 nb^{-1} Novembre)
Runs (ongoing) con **Ossigeno (~0.5 nb^{-1} O-O, ~2.5 nb^{-1} p-O) e Neon**

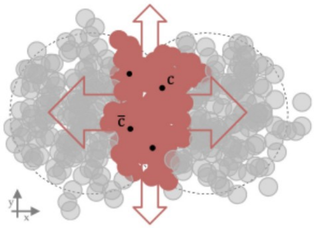
Principali motivazioni per O-O e p-O (public note, https://cds.cern.ch/record/2765973):
1) Capire come mai in "piccoli sistemi" (pp e pA) si osservino valori significativi di anisotropia azimutale, tipici di un sistema fortemente interagente come il QGP ma non segnali di perdita di energia delle particelle energetiche -> O-O sistema intermedio tra p-Pb e Pb-Pb periferico
2) Studio sezioni d'urto per fisica dei raggi cosmici

Gruppo PD: contributo a motivazioni di fisica
(A. Dainese, A. Rossi)
Contributo ad analisi dati





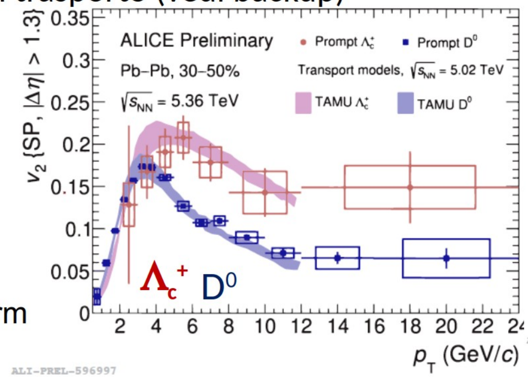
Risultati di fisica (focus gruppo PD)

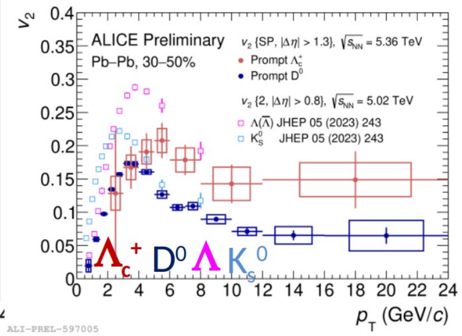


Misure del *flusso ellittico*(v_2) di mesoni (D^0) e barioni (Λ_c) con charm
- parametrizza anisotropia azimutale (v_2 = coeff. seconda armonica Fourier)
- Essenziale per vincolare l'adronizzazione del charm nel mezzo e misurare coefficienti di trasporto (vedi backup)

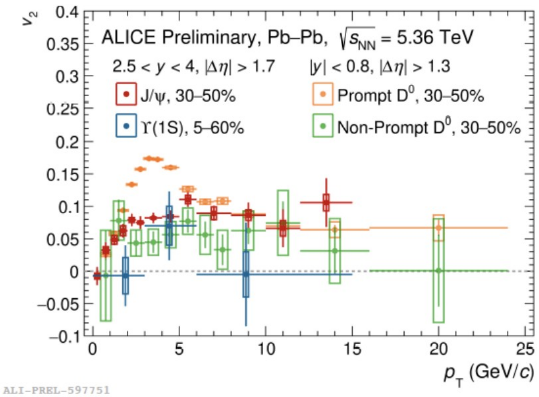
v_2 (Λ_c , D^0) >>0 [prima misura *ever* v_2 (Λ_c)]
v_2 (Λ_c) > v_2 (D^0) ad alto momento
"Splitting" barione/mesone simile a quanto avviene per light-flavour

Atteso da modelli (TAMU) con
- Breve tempo di rilassamento del charm
- Adronizzazione tramite **coalescenza**





Misura della componente "non-prompt" da decadimenti di beauty:
v_2 ($D^0_{\text{non-prompt}}$) < v_2 (D^0): in linea con maggiore tempo di rilassamento dovuto a maggiore massa del beauty => importante test degli effetti della massa del quark
v_2(J/ψ) < v_2 (D^0), v_2(Υ) ~0, < v_2 ($D^0_{\text{non-prompt}}$): importanza contributo v_2 quark leggeri a v_2 adrone



ALICE
A. Rossi

Risultati di fisica (focus gruppo PD)

Fattore modificazione nucleare:
$R_{\mathrm{PbPb\,[pPb]}}$ = Yield PbPb [pPb] / (Yield pp x N_{coll})

dove N_{coll} = numero collisioni binarie nucleone-nucleone

$R_{\mathrm{PbPb\,[pPb]}}$ = 1 -> no effetti nucleari
$R_{\mathrm{PbPb\,[pPb]}}$ < 1 (*):
- **modifica PDF (e.g. gluon shadowing)**
- modifica abbondanze relative specie adroniche
- annichilazione nel mezzo quark/adroni significativa e maggiore della generazione nel mezzo

Per il charm:
- misure Λ_c^+/D^0 indica (con incertezze significative) che le abbondanze (integrate in momento) relative cambiano poco da pp a PbPb
- l'annichilazione e generazione di coppie ccbar si assume sia piccola

→ Misura suggerisce effetto di shadowing in Pb-Pb per il charm (prompt D^0), non apprezzabile per D^0 da beauty

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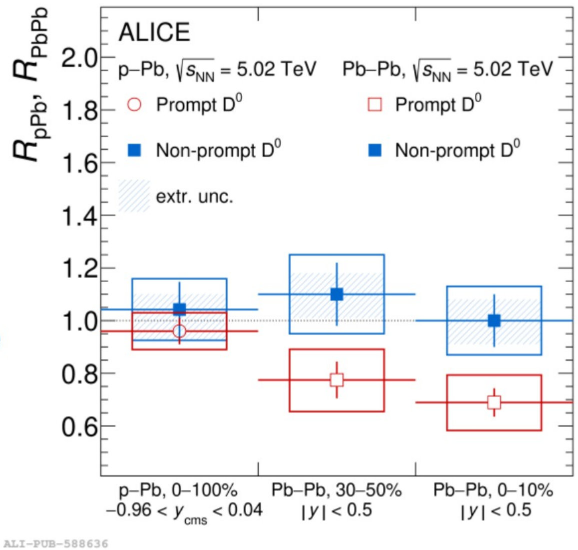
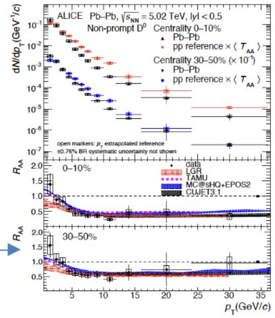


(*) se misurato in funzione del momento R_{PbPb} è determinato sostanzialmente dalla dinamica nel mezzo, e.g. dalla perdita di energia



Preventivi 2025: anagrafica e ruoli

Snapshot Luglio 2025

	2024 (N)	2024 (FTE)	**2025 (N)**	**2025 (FTE)**
Ricercatori + PhD	13	10.1	**18**	**14,8**
Tecnologi	4	0.8	**4**	**0.8**

Nuovi membri, **uscite** (rispetto a Luglio 2024)

Ricercatori: Antinori (100%), Dainese (90%), Giubilato (70%), Lunardon (30%), Mattiazzo (70%), Rossi (90%), Soramel (70%), Turrisi (50%)

Assegnisti: Chiappara (70%, in scadenza), Faggin (100%), Peng (100%), Sharma (100%), Singh (100%

Dottorandi: Pantouvakis (70%), Rignanese (100%), C. Wu (100%, bando CSC), M. Zhang (100%, cotutela Wuhan), Zingaretti (70%)

Tecnologi: Benettoni (20%), Guang Meng (40%), Rebesan (20%), Sgaravatto (10%)

Responsabilità nella collaborazione:

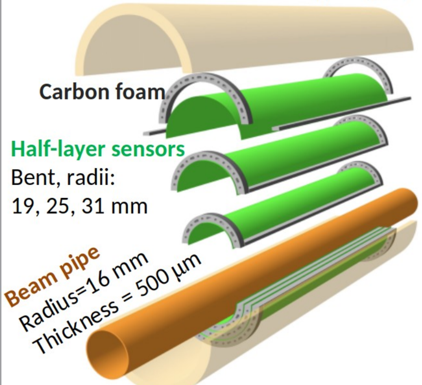
- Antinori: Responsabile Nazionale
- Dainese: Upgrade Coordinator
- Faggin: coordinato gruppo analisi dati di misure di barioni e mesoni con charm e beauty
- Giubilato: ITS3-upgrade, responsabile work-package sviluppo readout
- Rossi: ITS3-upgrade physics performance (coordinatore), Collaboration Board (membro)
- Turrisi: deputy responsabile nazionale calcolo

Articoli ALICE ultimi 12 mesi ~40 (43 in tutto il 2024, 17 nel 2025)

Contributo diretto gruppo di Padova: 3 (+ 4 come coord. o revisione)+ 2 documenti tecnici (TDR, Scoping document) + 1 workshop-summary + 1 articolo di review

ALICE
A. Rossi

Upgrade: ITS3 per run 4



Design innovativo (evoluzione di ITS2), nuova tecnologia

- sensori a pixel di silicio delle dimensioni del wafer (tecnica dello stitching), tecnologia 65 nm TJ, pixel pitch ~22 x 22 µm²
- ultrasottili (~50 µm Si, $<x/X_0>_{layer}$ ~0.07%), elettronica ai bordi, basso consumo (<40 mW/cm²), raffreddamento ad aria
- sensori curvati a forma di semi-cilindri

Stato del progetto

- 2019 LoI (Dainese editor): http://cds.cern.ch/record/2703140
- 2023 Public Note (Rossi ed.) su Phys. Perf. estende LoI https://cds.cern.ch/record/2868015?ln=en
- 2024 TDR avallato da LHCC https://cds.cern.ch/record/2890181?ln=it
- **2025: Memorandum of Understanding** https://cds.cern.ch/record/2929822/ (restricted)

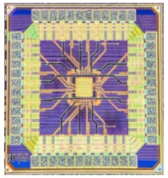
firmato da INFN a Gennaio

→ Fase di costruzione (costo core tot. ~3800 kCHF 2024-2027)

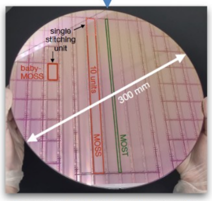
Tecnologia e disegno innovativo ✉ caratterizzazione, sviluppo, e ricerca (specifici per il progetto) anche fase di costruzione

Sviluppi ITS3 cruciali per NA60+ e EPIC
Ancora parziale sinergia

MLR1: strutture piccole (matrici di decine/centinaia di pixel)



ER1: strutture medie e grandi dimensioni



Engineering Run 1 wafer with various dies

ER2:
sensore dimensioni finali con funzionalità complete (MOSAIX)
Contributo Padovano al design software del sensore: D. Chiappara
(simil fellow, CERN fellow a Novembre)

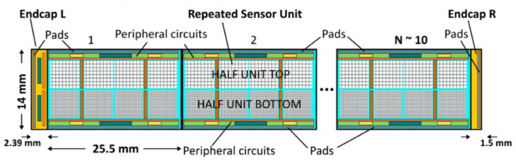
Qualification model

Responsabilità e attività a Padova (2024-2025):

- Test in sezione su matrici di piccole e medie dimensioni da sottomissione ER1 (Mattiazzo)
- Responsabilità coordinazione work-package sviluppo read-out (Giubilato)
- Coord. work-package Physics performance, reconstruction and simulation (Rossi)

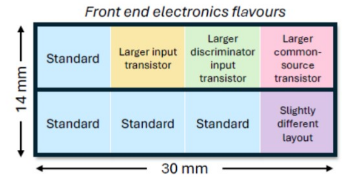
ITS3: attività a Padova (2024-2025)

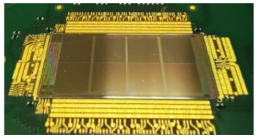
MOSS



- MOSS (MOnolithic Stitched Sensor) prototipo prodotto a Dicembre 2023 che utilizza la tecnologia dello stitching
- Dimensioni di 1.4 cm x 26 cm, composto da 10 RSU (Repeated Sensor Unit)

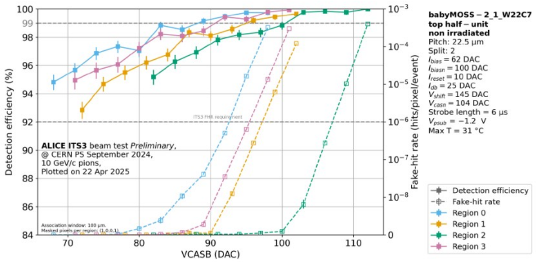
babyMOSS



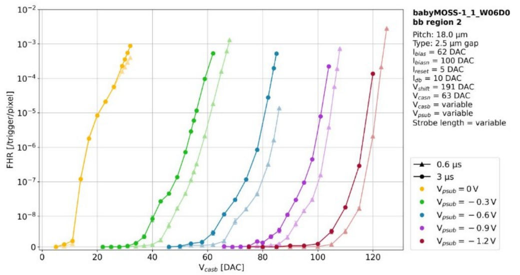


- Prototipo composto da una sola RSU per caratterizzazione a testbeam e su sensori irraggiati

- **Test beam al CERN PS (settembre 2024)**
  - BabyMOSS telescope (6 tracking planes)
  - Tested 3 babyMOSS DUTs: 1 non irradiated, 2 irradiated to 10^{13} n_{eq}/cm^2
  - Misura dell'efficienza di tracciatura e della risoluzione spaziale

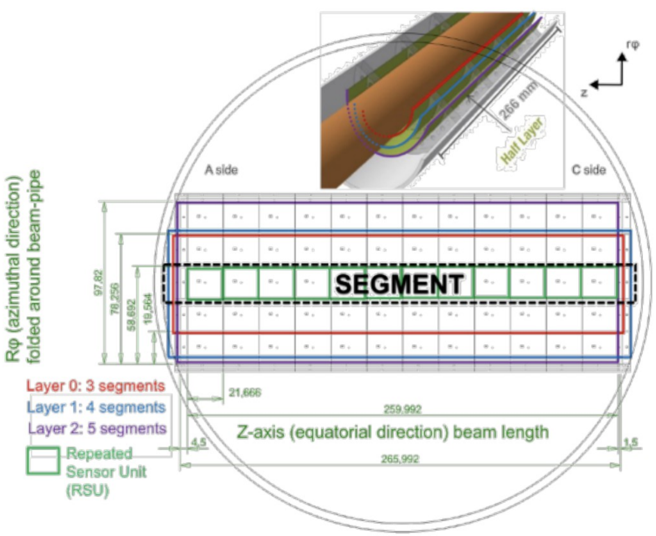


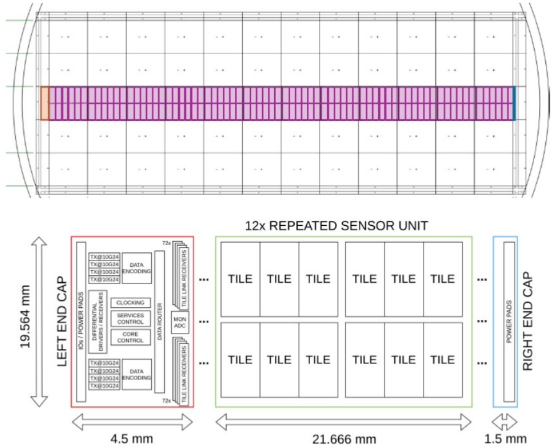
- **Test in laboratorio**
  - BabyMOSS: misura del fake hit rate in funzione dei parametri del frontend
  - Test e calibrazione con sorgenti



ITS3/ALICE3: attività a Padova (2026)

- **MOSAIX:**
  - Prototipo di sensore per ITS3 "stitched", full size, fully functional
  - Produzione da sottomissione ER2 in corso (fase finale di validazione).
- **2026: Test sul chip + realizzazione test system per sviluppo readout**
  - Sviluppo software di test (già iniziato nel 2025)
  - DAQ in fase di acquisizione
  - Test in laboratorio: primavera 2026





ALICE 3

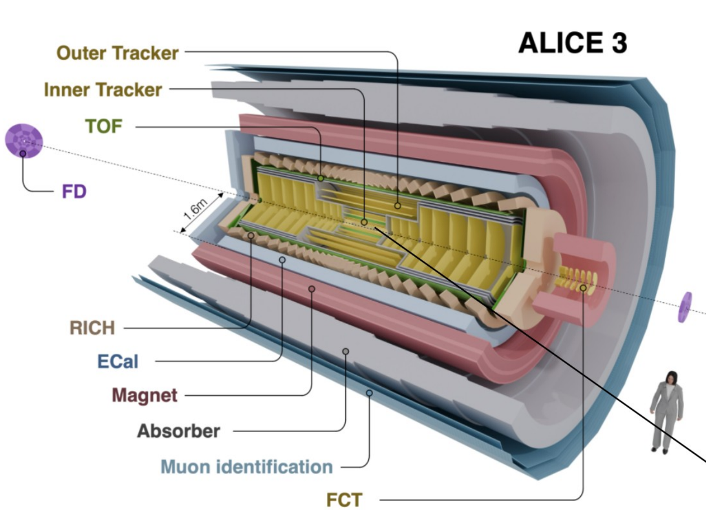
Letter of intent approvata da LHCC a Marzo 2022 (F. Antinori tra i main editors)

“A next generation heavy-ion experiment at the LHC”, https://cds.cern.ch/record/2803563.

- Rivelatore compatto e leggero, con tracciatore al silicio e rivelatore di vertice retrattile dentro la beam pipe.
- PID (Si TOF, RICH) + Muoni + ECal
- Accettanza grande

Operativo nel Run 5 (2035), timeline:

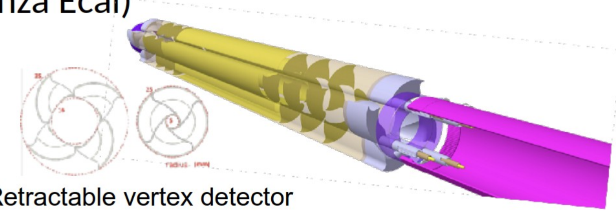
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	Run 3				LS3				Run 4			LS4	
ALICE 3	Detector scoping, WGs kickoff	Selection of technologies, R&D, concept prototypes		R&D, TDRs, engineered prototypes		Construction				Contingency and precommissioning		Installation and commissioning	



Ultimo anno/in corso:

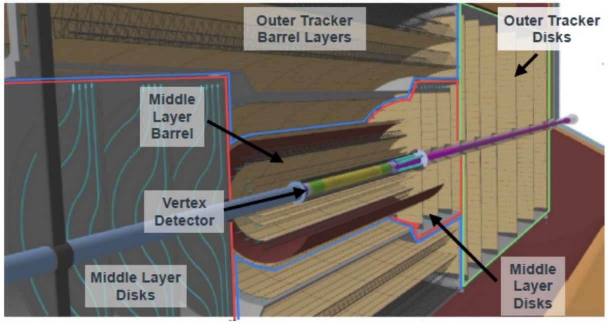
- Scoping document (A. Dainese main editor): CERN-LHCC-2025-002
    - detector scope vs physics programme
    - definizione linee R&D, piano delle risorse

=> raccomandazione LHCC: intermediate scope (senza Ecal)



Retractable vertex detector

ALICE3: contributo gruppo PD



Interessi principali gruppo di Padova

Silicon tracker: middle layers (7 < *R* < 20 cm)

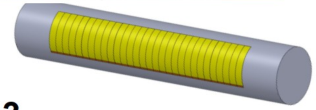
(+ vertex detector)

Continuazione di R&D per ITS3

Attività:

1) Valutazione diverse geometrie middle layers

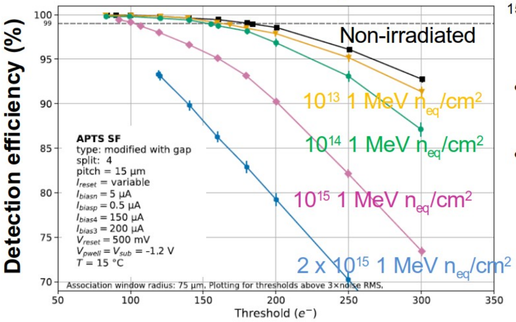
- Base (LoI): standard staves
- Geometrie alternative (P. Giubilato, 2024) con sensori curvi
- **Design ibrido: staves con sensori curvi** (studi e valutazioni in corso da gruppi INFN)
  → minor material budget (migliori risoluzioni spaziali e momento)



→ Possibile coinvolgimento in attività di Meccanica (Benettoni) in via di definizione

2) Contributo a caratterizzazione sensore, in continuazione con attività ITS3

Alcune strutture di test per ITS3 sono state testate (anche a Padova, 2023) per i livelli di irraggiamento previsti in ALICE3



^{15} n_{eq}/cm^2 → **fluenze in ALICE3: 10^{15} - 10^{16} n_{eq}/cm^2**

- Per poter testare rivelatori irraggiati a queste dosi, è necessario farlo a **basse temperature** (-20°C)
- Necessità di effettuare i test in ambiente controllato (temperatura e umidità): **necessaria camera climatica**
  → **richiesta contributo acquisto (20-25 k€ su totale → 30 k€)**

Richiesta (~10 k€) per contribuire (EPIC, FCC,…) acquisto wedge bonder semiautomatica → in discussione

Nel presente Engineering Run (ER2) e nel successivo (ER3) sono incluse delle strutture di test specifiche per ALICE 3, che dovranno essere bondate su delle schede di test

Interesse trasversale fra vari esperimenti per attività di R&D su sensori nei prossimi 20 anni

→ Ammodernamento della strumentazione del Servizio di Tecnologie Avanzate

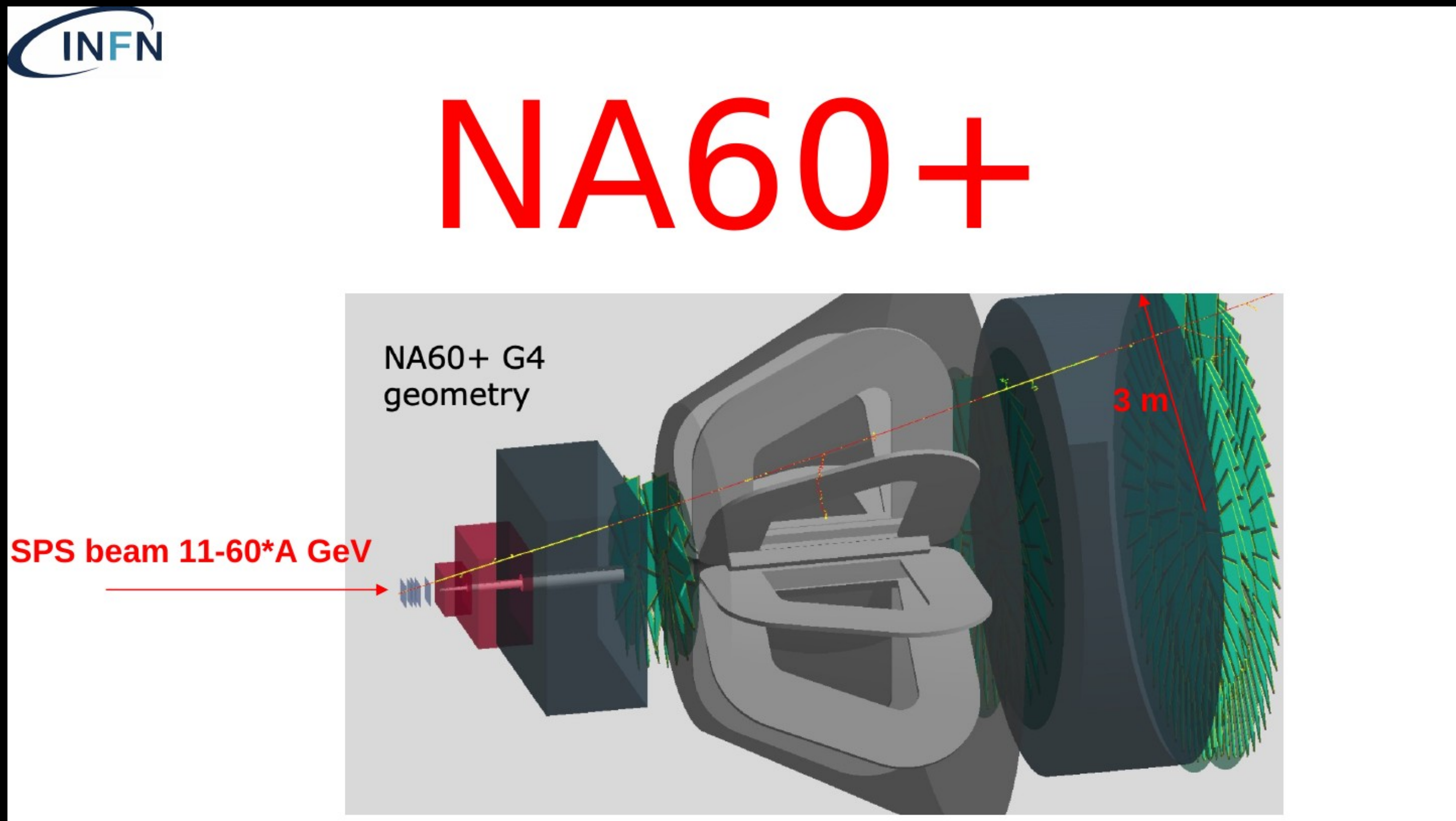
Richieste per 2026

Capitolo	Richiesta
Trasferte	~113.5 k€
Impianti (Inventario)	30-35 k€
Consumo	8 k€
Trasporti	2 k€

Missioni: valore da parametri ALICE-Italia in base a FTE e responsabilità + attività in ITS (inclusi upgrades). Essenzialmente trasferte al CERN per riunioni e presa dati + lavori e testbeam per ITS3
Impianti: 25 k€ per camera climatica, 10 k€ (in discussion) contributo bondatrice (richiesta EPIC)
Consumo: ~5 k€ per ALICE3 + 3 kCHF per macchina CERN (turni)

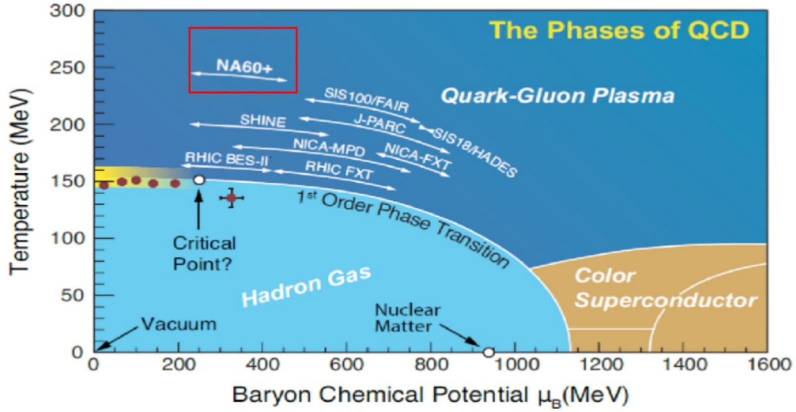
IN DISCUSSIONE

Servizio Sezione	Richiesta
Officina elettronica	6 m.u.
Officina meccanica	2 m.u.
Ufficio tecnico	2 m.u.

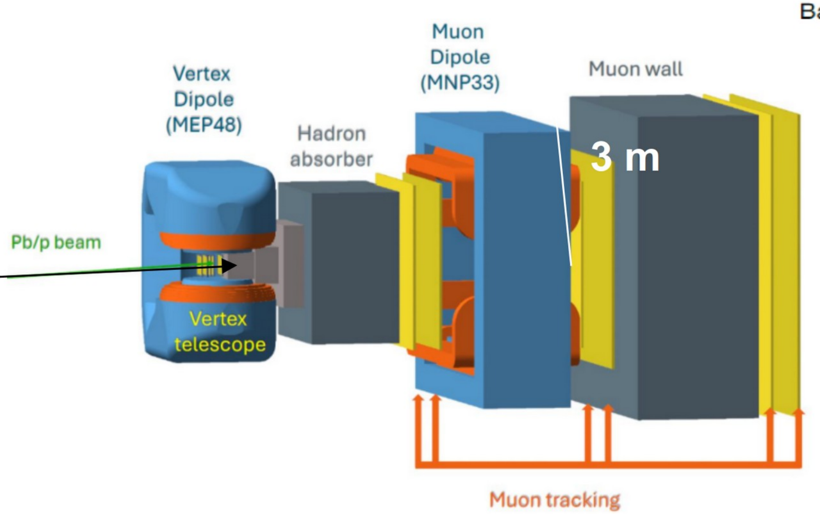

NA60+
NA60+ G4
geometry
3 m
SPS beam 11-60*A GeV

NA60+

- Fixed-target experiment at the CERN SPS
- Dimuon spectrometer with a silicon tracker
- Study QGP properties at lower temperature and higher baryon density than at LHC
- Look for onset of colour deconfinement



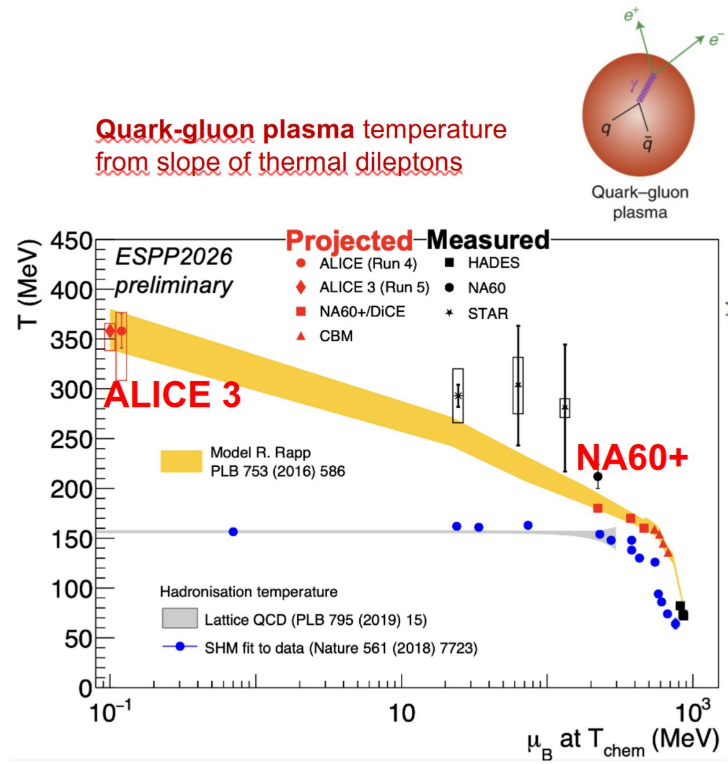
SPS Pb beam
11-60 A GeV



NA60+
A. Dainese

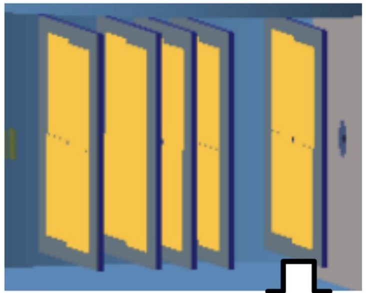
NA60+: activities 2024 and 2025

- Letter of Intent approved by SPS Committee in 2023
  - https://cds.cern.ch/record/2845241
- Main physics goals:
  1. Caloric curve of strongly-interacting matter with thermal radiation (dimuons)
  2. Chiral symmetry restoration with ρ-a_1 meson mixing
  3. Charm production and diffusion coefficient close to critical QCD temperature
  4. Onset of J/ψ suppression due to colour screening
- **Experiment Proposal submitted in May**



NA60+: activities 2025 and 2026

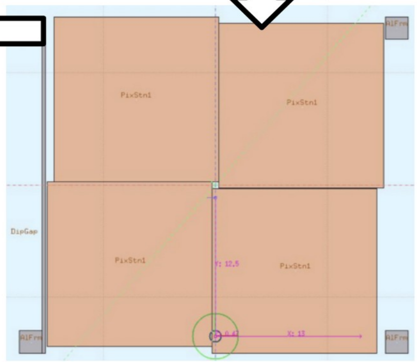
- R&D on monolithic silicon pixel sensors
- Specs: thickness ~40 μm, resolution ~5 μm, few large-area sensors
- NA60+ will use the sensors and readout system developed for the ALICE ITS3



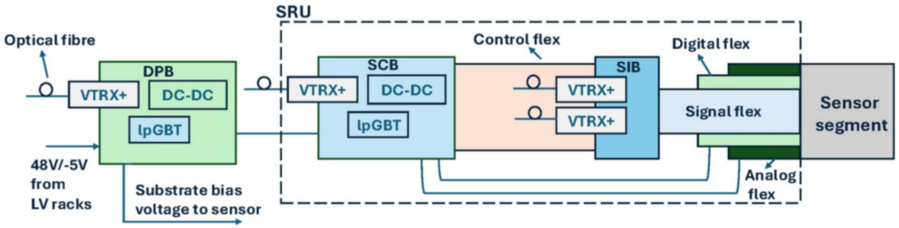
Padova participates in the sensor tests and readout system design, in collaboration with Cagliari
→ ALICE/ITS3 slides

4 large sensors x 5 planes

7 MOSAIX segments



Adapted from ITS3 readout chain



Preventivi 2026 NA60+: anagrafica e richieste

- Sigla "network" dal 2020 in CSN3
  - Resp. nazionali: E. Scomparin, G. Usai
  - ~ 4 FTE: Cagliari+Torino+Padova

- Anagrafica Padova: 0.2 FTE
  - A. Dainese (resp. loc.), A. Rossi;

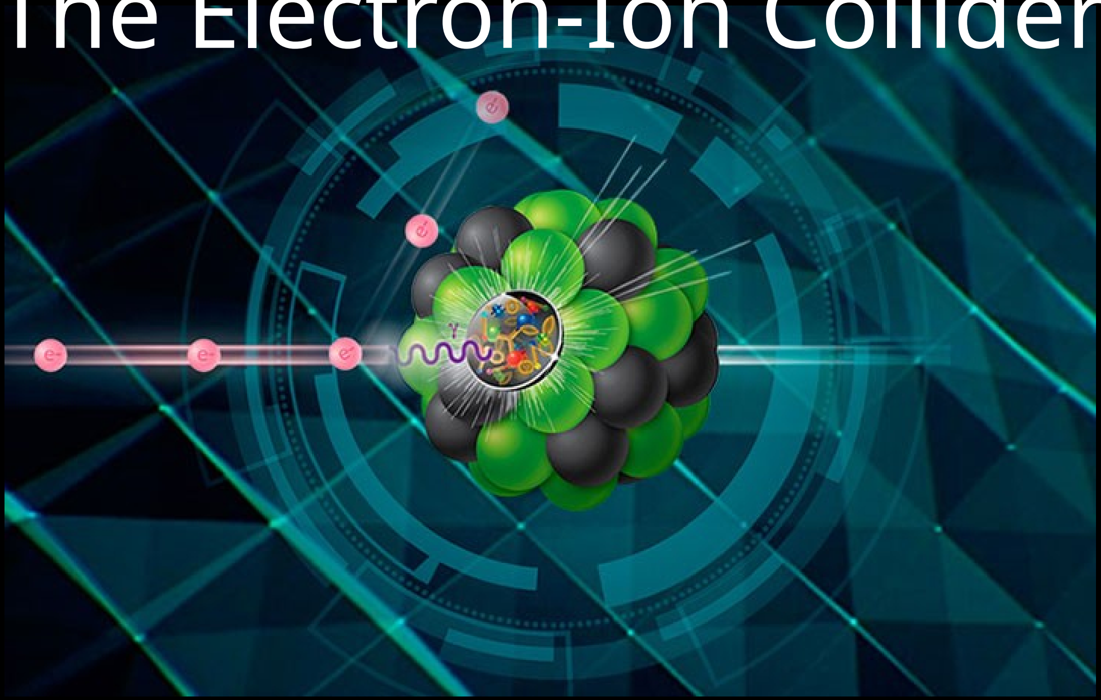
- Richieste: ~ 1.5 + 1.5 s.j. kE, per riunioni di Collaborazione al CERN e eventuale partecipazione test beam per pixel telescope (s.j. a disponibilità prototipi)
- Non ci sono richieste ai servizi

EIC/ePIC
R. Turrisi

1 Quarks and hadron dynamics

EIC_NET → ePIC

The Electron-Ion Collider



ePIC

INFN PADOVA
Istituto Nazionale di Fisica Nucleare
Sezione di Padova

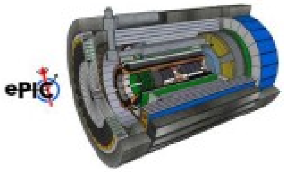
EIC_NET

Rosario Turrisi

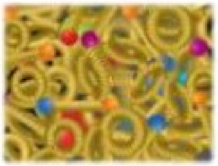
dal 2025 **EIC_NET** diventa **ePIC** !
Passaggio a sigla ''R&D e costruzione''
Approvato il 18 giugno 2024 in CSN3

EIC project status and timeline

EIC (and ePIC) in a nutshell



- enable ultimate QCD exploration:
  - ✓ by a high-luminosity polarized electron-ion collider: **EIC**
  - ✓ by a detector highly integrated with the collider, able to cope the EIC physics scope: **ePIC**
- main questions to be addressed:
  - ✓ how does the **mass** of the nucleon arise?
  - ✓ how does the **spin** of the nucleon arise?
  - ✓ what are the emergent properties of **dense system of gluons**?
  - ✓ how are the **quarks and gluon distributed in space and momentum** inside nucleon and nuclei?



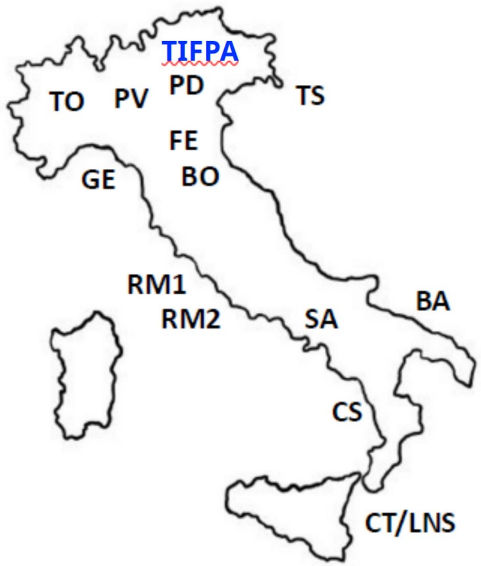
- current status:
  - ✓ EIC **approved project progressing towards its realization** at BNL in cooperation with JLab
  - ✓ ePIC Collaboration **established with > 1000 members and high international character**

ePIC Italia organization and size

INFN groups and coordination team:

- **15 INFN units**: largest cluster within CSN3
  - ✓ 14 units till 2025, TIFPA officially joining from 2026
- **CEI (Comitato ePIC Italia):**
  - ✓ RN, 15 RLs and 1 Theory representative: M. Radici (PV)
- **Coordination team:**
  - ✓ **dRICH**: M. Contalbrigo (FE)
  - ✓ **SVT**: R. Turrisi (PD)
  - ✓ **uRWELL-ECT**: A. D'Angelo (Roma TV)
  - ✓ **Physics**: S. Fazio (CS) + SIDIS subgroup: S. Costanza (PV)
  - ✓ **Computing**: A. Bressan (TS) + deputy: F. Noferini (BO)
  - ✓ **Streaming RO**: M. Battaglieri (GE)
  - ✓ **Outreach**: M. Ruspa (TO)

ePIC Italia INFN units in 2026



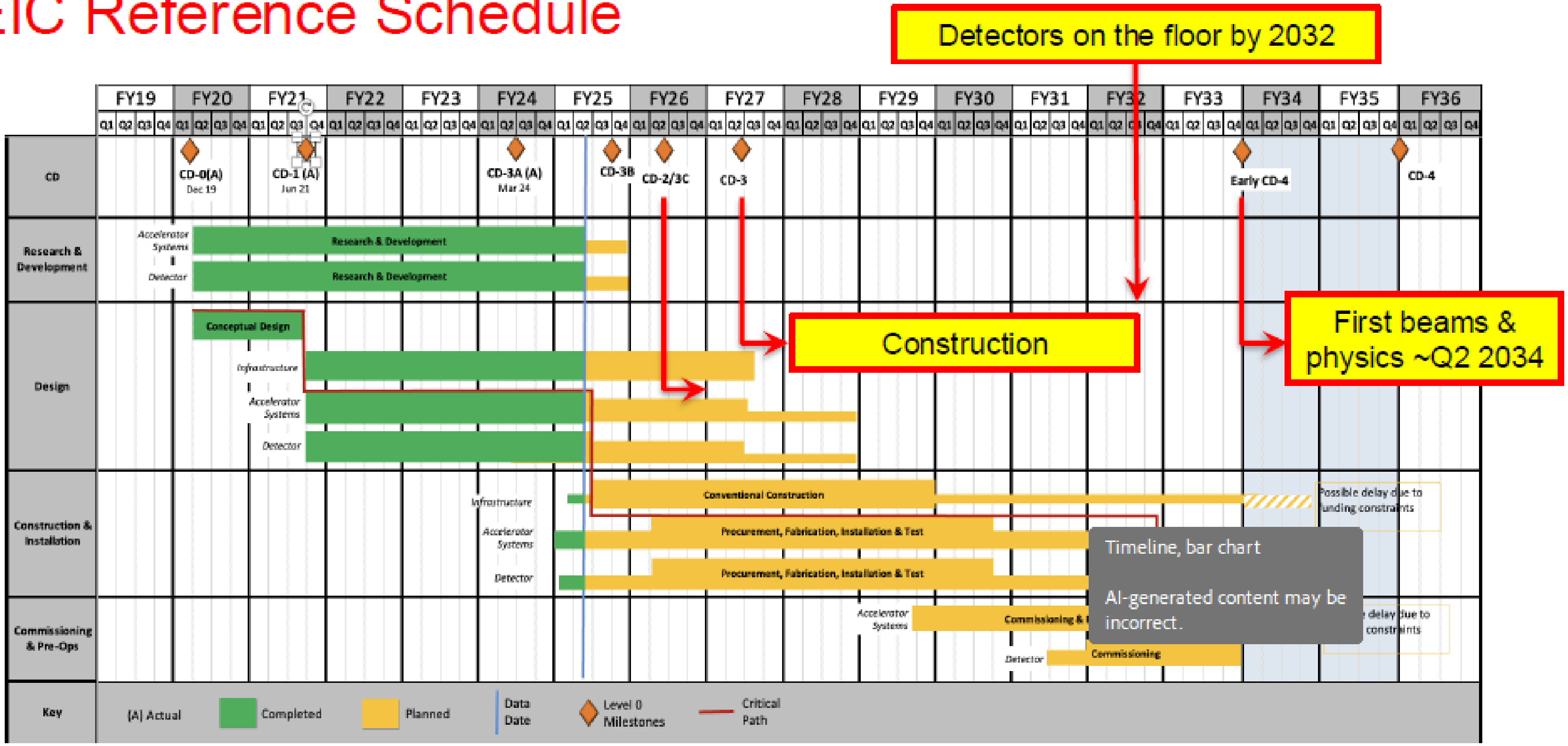
	2025	2026
Tot Persone	126,0	151,0
Tot FTE	38,8	52,8
FTE/Persona	0,31	0,35

Domenico Elia

ePIC @ INFN CSN3 meeting / Trieste - June 20, 2025

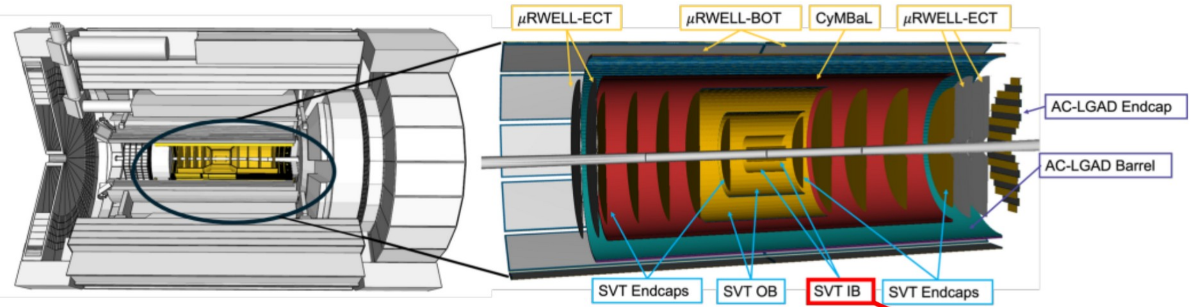
EIC project status and timeline

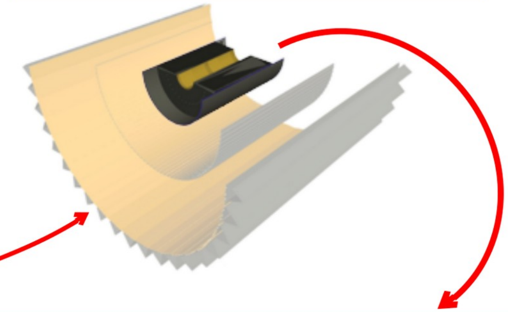
EIC Reference Schedule



SVT Inner Barrel

Silicon Vertex Tracker Barrel



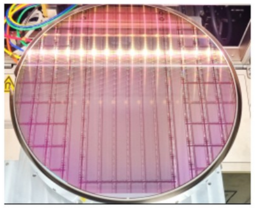


SVT-IB (L0,L1,L2):
Silicon Vertex Tracker – Inner Barrel

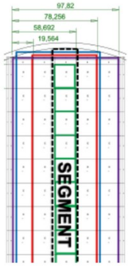
Tre strati, attualmente l'INFN ha responsabilità costruzione dei due più interni ;
L2 in fase di studio

Sensori: **MOSAIX (ALICE-ITS3)**, 65nm TPSCo, bent to cylindrical shape

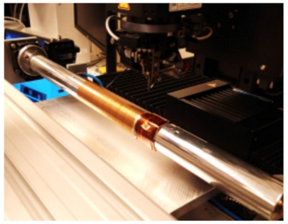
- Silicon thickness 50 μm
- Pitch 21 × 23 μm
- 40 mW/cm² power dissipation, transducers ~1600 mW/ cm² (LEC)
- 0.07% X/X_0 (Si+metal layers)
- ~ 1.9-3.2 g Si/sensor (L0-L2)



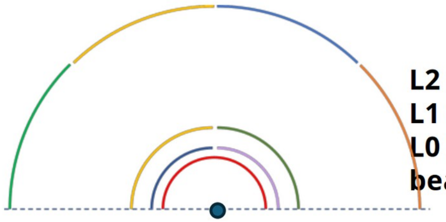
dal wafer...



al sensore...



al rivelatore cilindrico

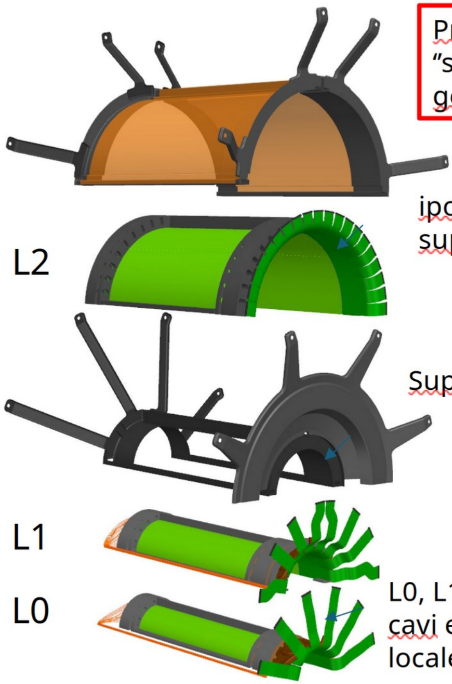


L2 (4 x sensors)	**r = 126 mm**
L1 (2x sensors)	**r = 50 mm**
L0 (2x sensors)	**r = 38 mm**
beam pipe	**r = 31.75 mm**

ePIC-Pd: Attività - parte 1

1. Progetto e realizzazione supporto globale IB ← **responsabilità verso la collaborazione**

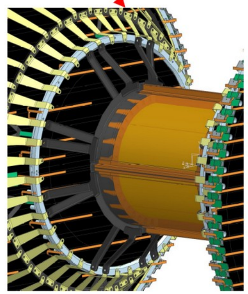
Progetto del supporto attualmente "stabile" e integrato nel CAD generale



ipotesi di supporto L2

Supporto in CFC L0+L1

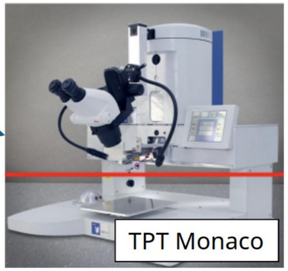
L0, L1 con sensori, cavi e meccanica locale



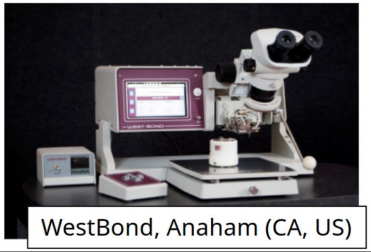
Integrazione nel CAD generale (in coll. con BNL)

2. Assemblaggio semibarili → task critica → **necessario** avere due centri produzione → candidatura Padova
   - Progetto tooling pronto (test già eseguiti a Bari)
   - Disponibilità servizi → carico molto limitato
   - NECESSARIA nuova macchina bondatrice → cofunding DOE-CSN-Pd-... (spesa <=81k iva inclusa)
     - Discussione con i referee in corso

bondatrici wedge-wedge con accettanza meccanica adatta ai layer di ePIC (2 emerse da ricerca di mercato)



TPT Monaco

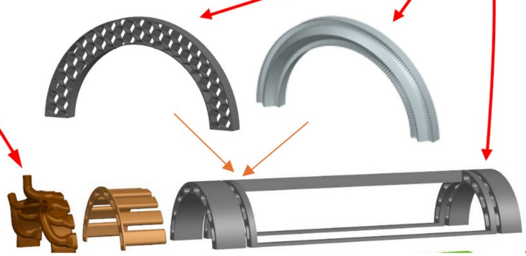


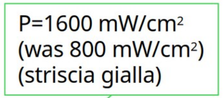
WestBond, Anaham (CA, US)

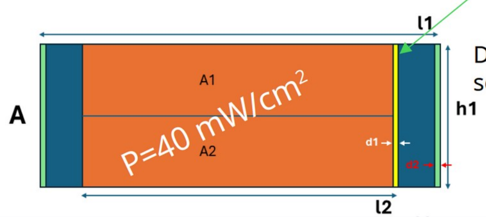
ePIC-Pd: Attività - parte 2

3. Realizzazione mock-up termico
   - test raffreddamento tramite ventilazione d'aria
   - test radiatori per area ad "alta" dissipazione

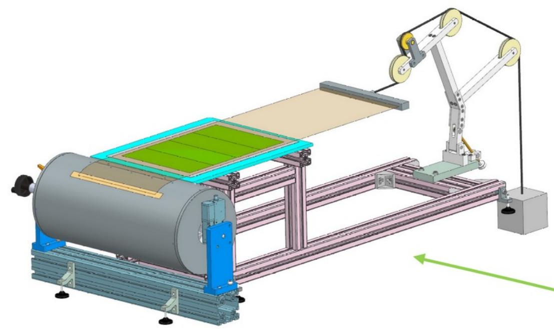
MOCK-UP TERMICO
- dummy heat load (kapton + rame) (realizz. M. Nicoletto)
- stampa 3D meccanica locale e globale
- stampa 3D convogliatori aria
- test progetti alternativi dissipazione calore (al posto di supporti in carbon foam)





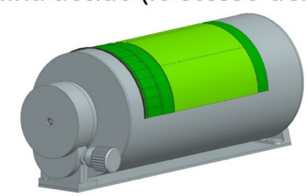


4. Studio fattibilità supporto e assemblaggio L2
   - piegamento di 4 sensori allineati (L0/L1 ne hanno 2)
   - in gran parte "estrapolato" dallo stesso lavoro per L0/L1



Setup per piegamento sensori (in comune per i tre layer, tranne parti dipendenti dal raggio)

Mandrino in polimero+lamina acciao (lo stesso della figura sopra), ⌀ 252 mm



ePIC Italia 2025

- https://agenda.infn.it/e/epicitaliapd
- Presso la Sala della Carità, Scuola della Carità di S. Francesco Grande
- 66 partecipanti, 16 talk su rivelatore, 10 su analisi e computing
- un intervento su MARCO (magnete superconduttore) di S. Farinon (INFN Genova) e su qualifica dei materiali di rivestimento della beam pipe per moderare la 'electron cloud' di M. Angelucci (LNF)
- Intervento di Thomas Ullrich, vice Chair dell'ePIC Collaboration Council, in collegamento da BNL, sullo stato e le prospettive dei programmi internazionali di finanziamento di R&D.
- Premiazione dell'evento di divulgazione con la presentazione di due video di divulgazione vincitori del concorso "Vi presento ePIC!" per studenti di scuole superiori

- Opening dei direttori DFA e INFN
- Supporto, indispensabile ed entusiasta, da amministrazione (Stefania, Marisol, Alessandra), segreterie scientifiche e di direzione (Pina, Elena, Marina, Giovanni), centro di calcolo (Michele, Massimo, Alberto), outreach (Alessandra, Sabine), STG (Enrico), Gruppo3 (Daniele)

GRAZIE !!!!!!!

(e scusate se dimentico qualcuno...)

ePIC-Padova: percentuali, richieste finanziarie e servizi

Richieste finanziarie in k€: **55.5** (PRELIMINARI, discussione con i referee in corso)

- missioni 10
  - test in altre sezioni, partecipazione a riunioni in Italia e in USA, ePIC ed SVT
- consumo 27
  - materiale per dispositivo assemblaggio L0,L1; test assemblaggio L2, strumentazione per test termici
- apparati 15
  - prototipo supporto meccanico globale in composito
- inventario 1.5
  - digiscope
  - IN DISCUSSIONE: 10 k€ contributo acquisto bondatrice per Servizio Alte Tecnologie
- trasporti 2
  - trasporto mock-up e materiali tra le sedi per test termici e meccanici

Richieste servizi, concordate con i responsabili:

Servizio	mesi-persona
Progettazione meccanica	5
Servizio Tecnologie Avanzate	3
Officina Meccanica	5
Officina Elettronica	1

FTE totale: 2.5

cognome	nome	FTE
Benettoni	Massimo	0.10
Chiappara	Davide	0.20
Ciarlantini	Sabrina	0.50
Giubilato	Piero	0.20
Mattiazzo	Serena	0.20
Pantouvakis	Caterina	0.30
Rebesan	Pietro	0.05
Turrisi	Rosario	0.50
Zingaretti	Alessandra	0.15

Esce: C. Bonini (post-doc)
Entra: A. Zingaretti (PhD stud.)

3 Nuclear Structure and reaction dynamics

4 Nuclear Astrophysics

Spring – Autumn 2022 Workshops Nuclear Physics Mid Term Plan in Italy


INFN

About Organizing Comittee REGISTER

This workshop is dedicated to future nuclear physics research in Italy with particular emphasis on INFN laboratories that are preparing important upgrades for the accelerators complexes.

The workshop is divided into three sessions, one for each laboratory:

Session 1 – LNS (April 2022)

Session 2 – LNL (April/May 2022)

Session 3 – LNGS/LNF (date to be announced)

The workshop will be prepared by researchers participating to specific working groups that will report their activities in the final events. These working groups will address the various research possibilities of the future experimental campaigns in the laboratories.

REGISTER

70 1951 2021 infn

Nuclear Physics Mid Term Plan in Italy

Laboratori Nazionali di Legnaro

Laboratori Nazionali del Sud

Laboratori Nazionali del Gran

Laboratori Nazionali di Frascati

3 Nuclear Structure
and reaction dynamics

GAMMA

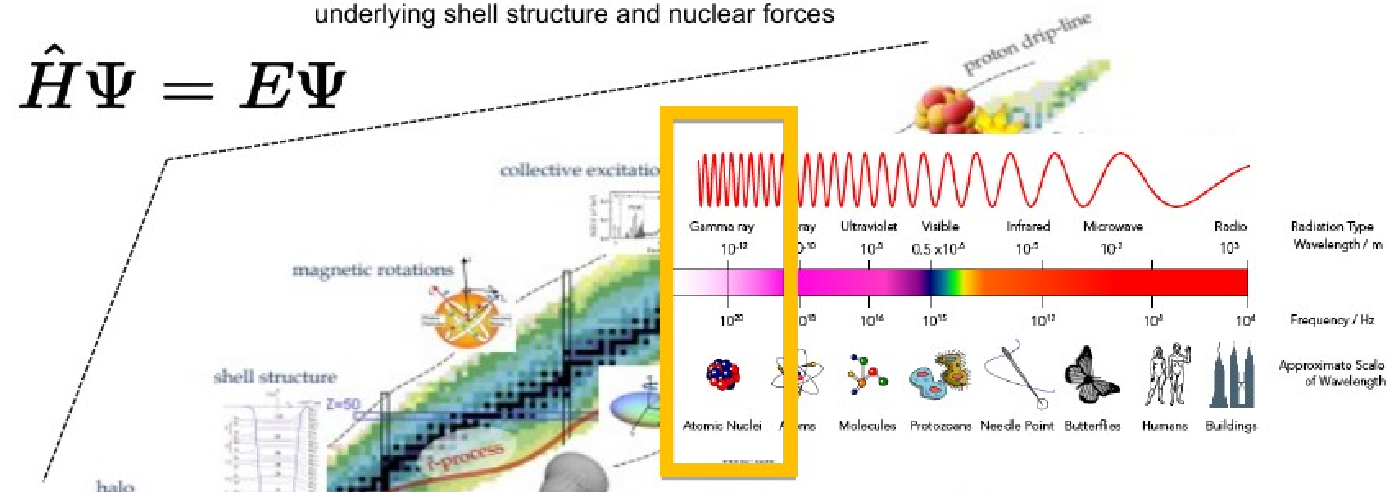
Unraveling the nuclear many-body problem

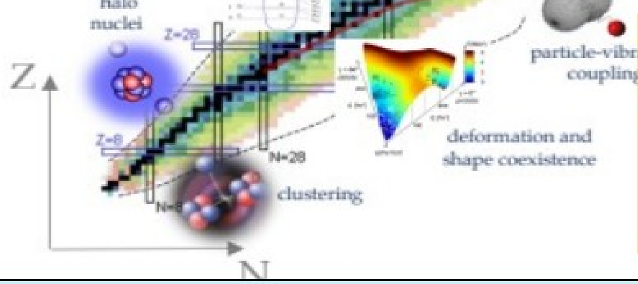
Three fundamental forces in nuclei: strong, weak and electromagnetic

Emergent phenomena from the same Hamiltonian

underlying shell structure and nuclear forces

$$\hat{H}\Psi = E\Psi$$





- Large fraction of the de-excitation of the excited nuclear levels goes via gamma emission
- Electromagnetic interaction well know and therefore ideal prove to study atomic nuclei.

$$\hat{O}_{\lambda\mu}(E\lambda) = \Sigma_i (r_i)^\lambda Y_{\lambda\mu}(\theta_i, \varphi_i)$$

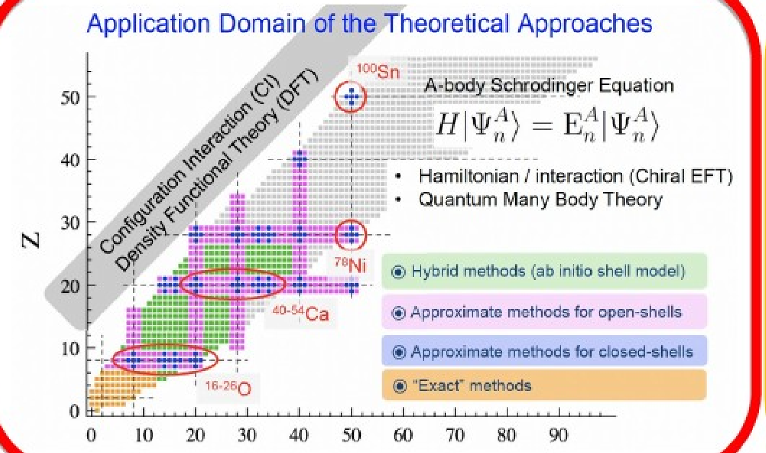
Variety of quantum phenomena, with an energy domain that goes from **few eV to GeV**.

Required a **comprehensive theory** that *describes quantitatively and predicts* the properties of the entire nuclear landscape
→ Gamma spectroscopy can contribute to this endeavour

How to approach such endevour?

The nuclear structure is not an observable. The nucleus is a many body object → need to measure in the laboratory various observables to constrain the nuclear models

The progress in the understanding of nuclei is driven by major advances of **theoretical** and **experimental** **tools**.



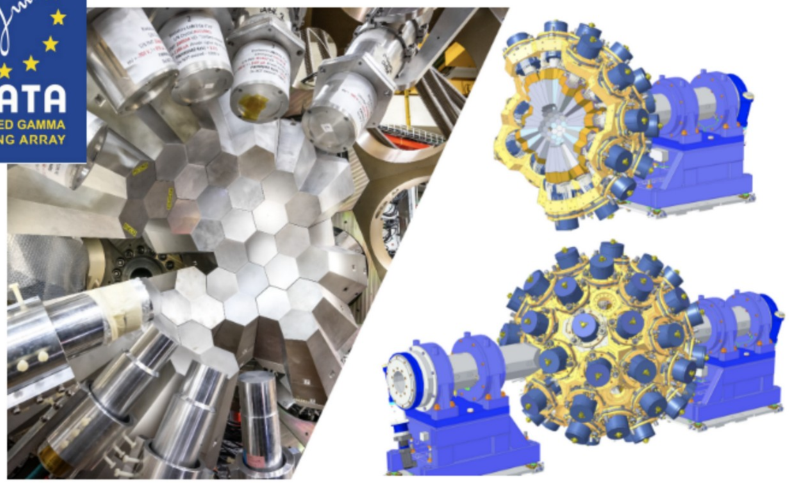
Theory development

Experimental apparata and facilities

AGATA IN ONE SLIDE

AGATA
ADVANCED GAMMA TRACKING ARRAY

S. Akkoyun et al., NIMA 668, 26 (2012)

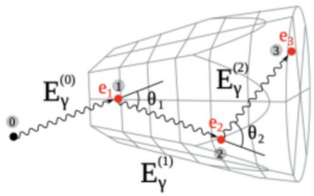


- **Continuous array**
- **180** hexagonal crystals in 60 ATCs
- Solid angle coverage: 82 %
- 36-fold segmentation: 6480 segments

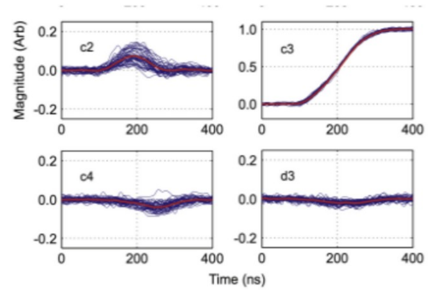
Unprecented sensitivity thanks to:

- Intrinsic high resolution of HPGe
- Position sensitivity:
  1. HPGe segmentation
  2. Digital electronics
  3. Dedicated software developments

Pulse shape and tracking

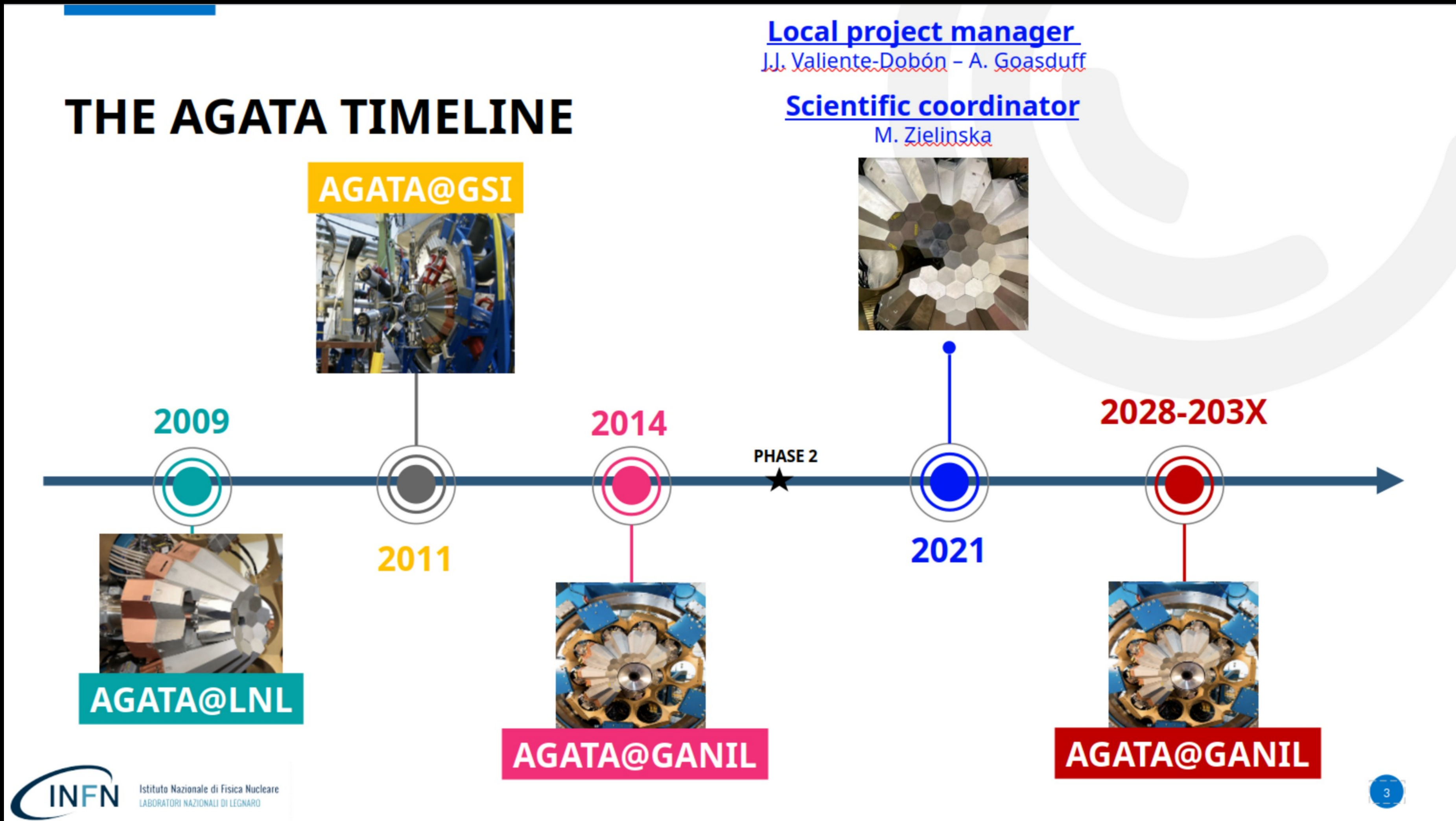


γ-ray energy and direction after Compton scattering



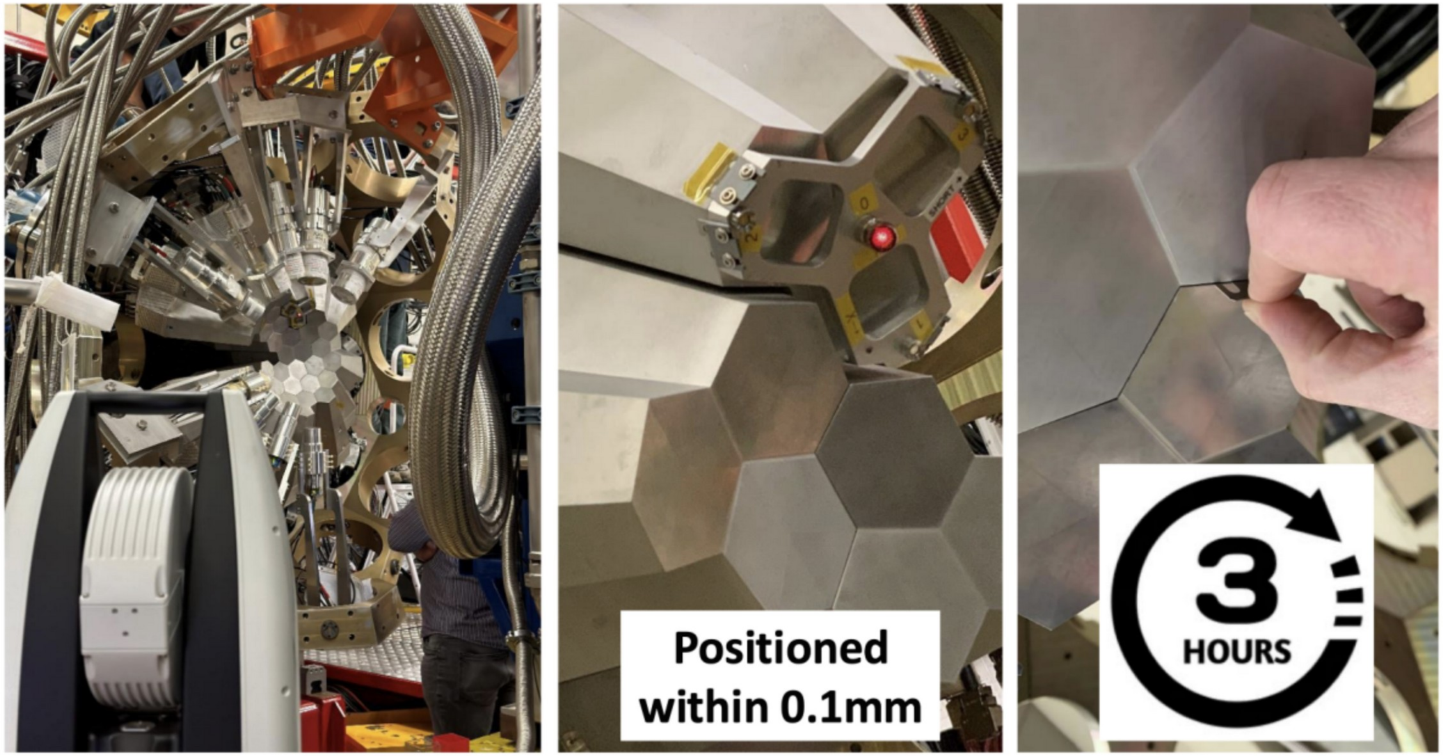
~ 5 mm (FWHM) position resolution

GAMMA
R. Menegazzo



GAMMA
R. Menegazzo

AGATA DETECTORS REPLACEMENT

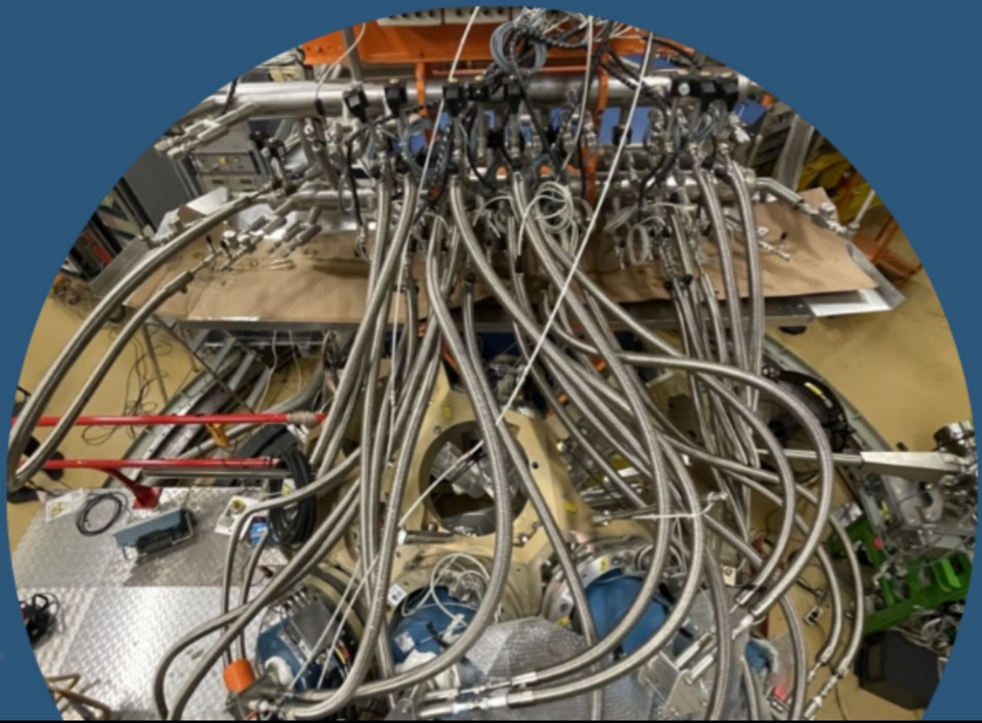


INFN Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI LEGNARO

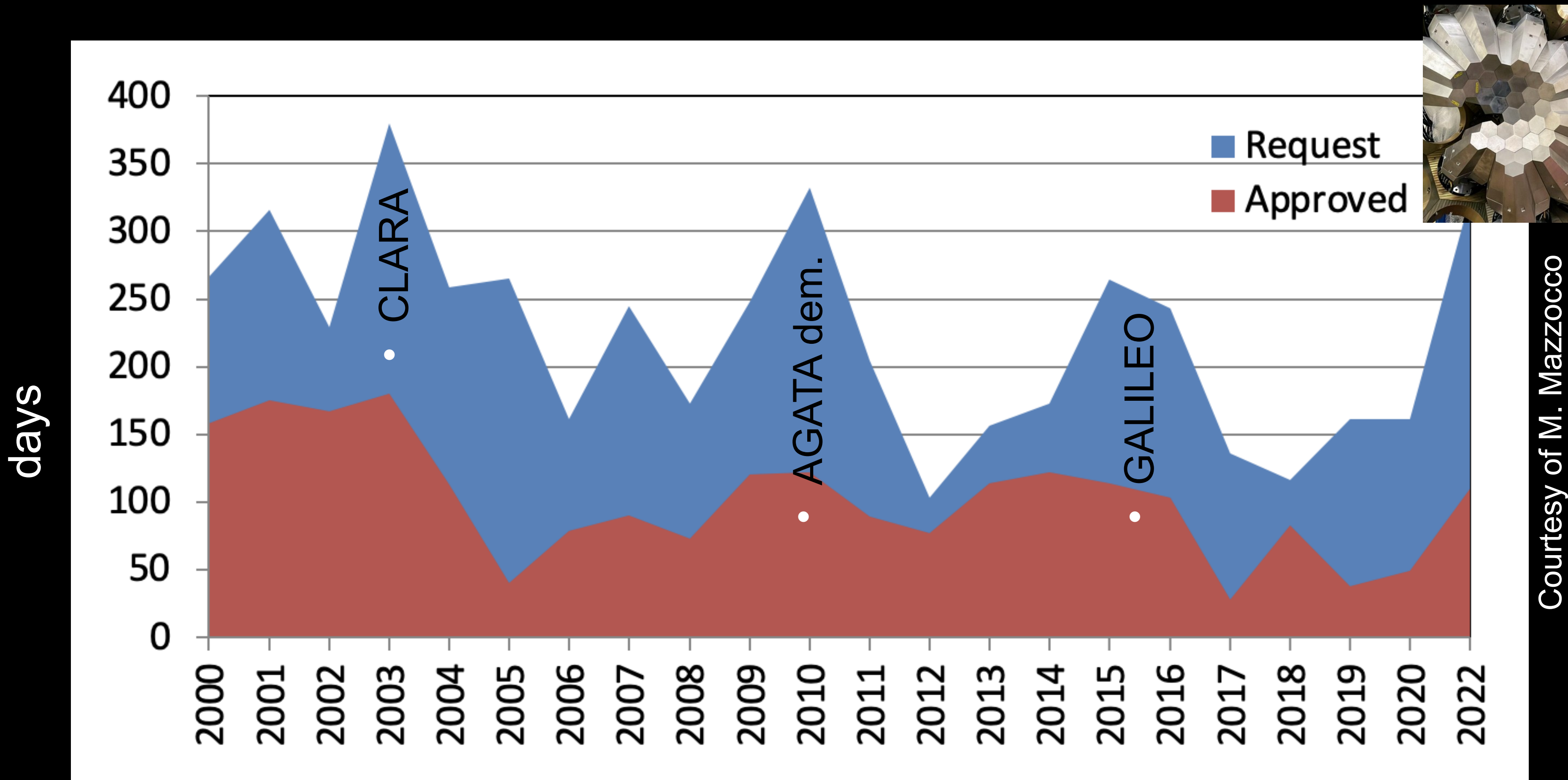
Courtesy of W. Raniero, D. Scarpa

THE AGATA-PRISMA CAMPAIGN

2022 - mid-2026



INFN Istituto Nazionale di Fisica Nucleare LABORATORI NAZIONALI DI LEGNARO



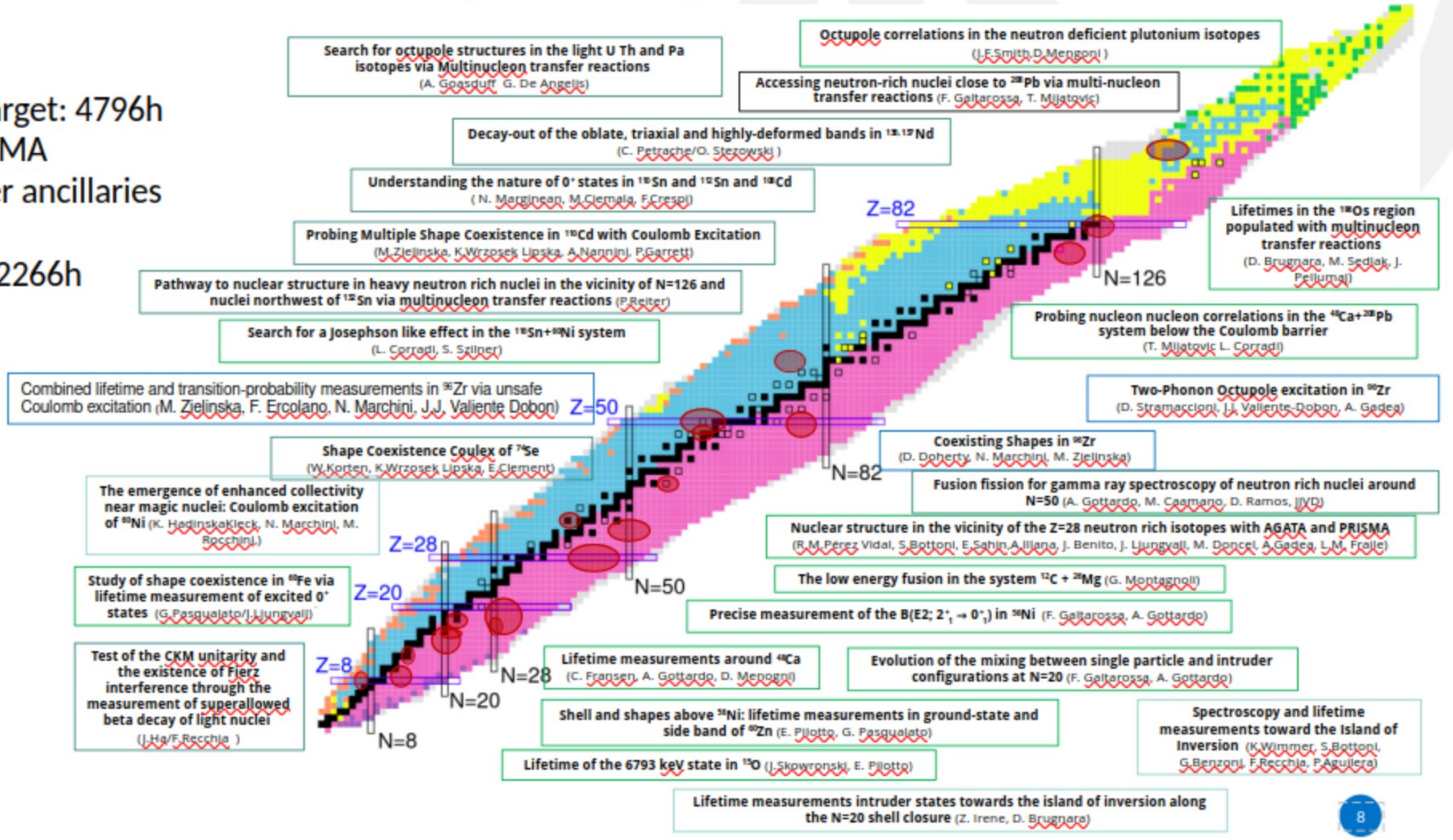
Courtesy of M. Mazzocco

- Coming week July 2024 PAC – probably December 2024
- There will be two PACs per year

THE PHYSICS CAMPAIGN (SO FAR)

For 2022-2023:
- Beam time on target: 4796h
- 2680h with PRISMA
- 2116h with other ancillaries

For 2024:
- Beam on target 2266h



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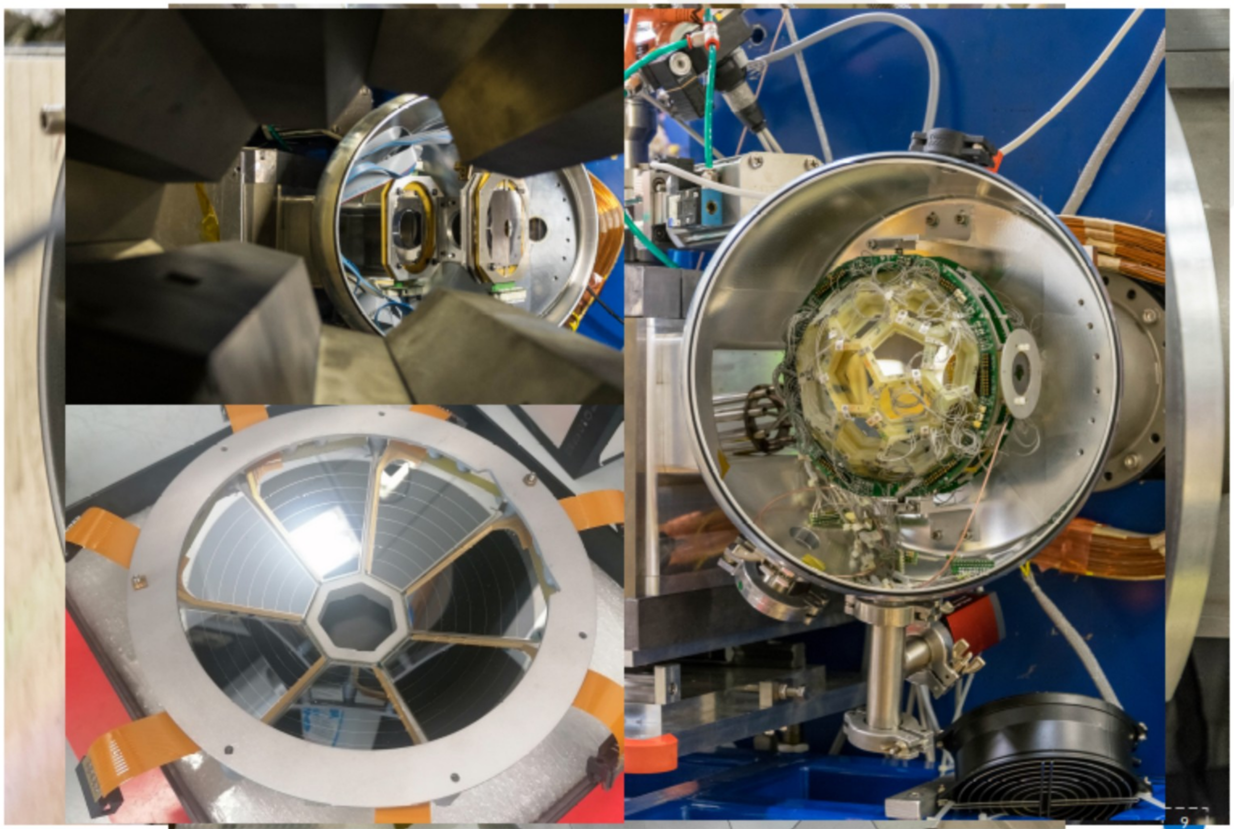
A WEALTH OF COMPLEMENTARY DETECTORS

1. Heavy ions:
   - PRISMA
   - SPIDER
   - DANTE
   - OSCAR
2. Light charged particles:
   - SPIDER
   - EUCLIDES
   - SAURON
3. Lifetimes
   - Plungers
4. Scintillators
   - $LaBr_3$



Courtesy of M. Balogh

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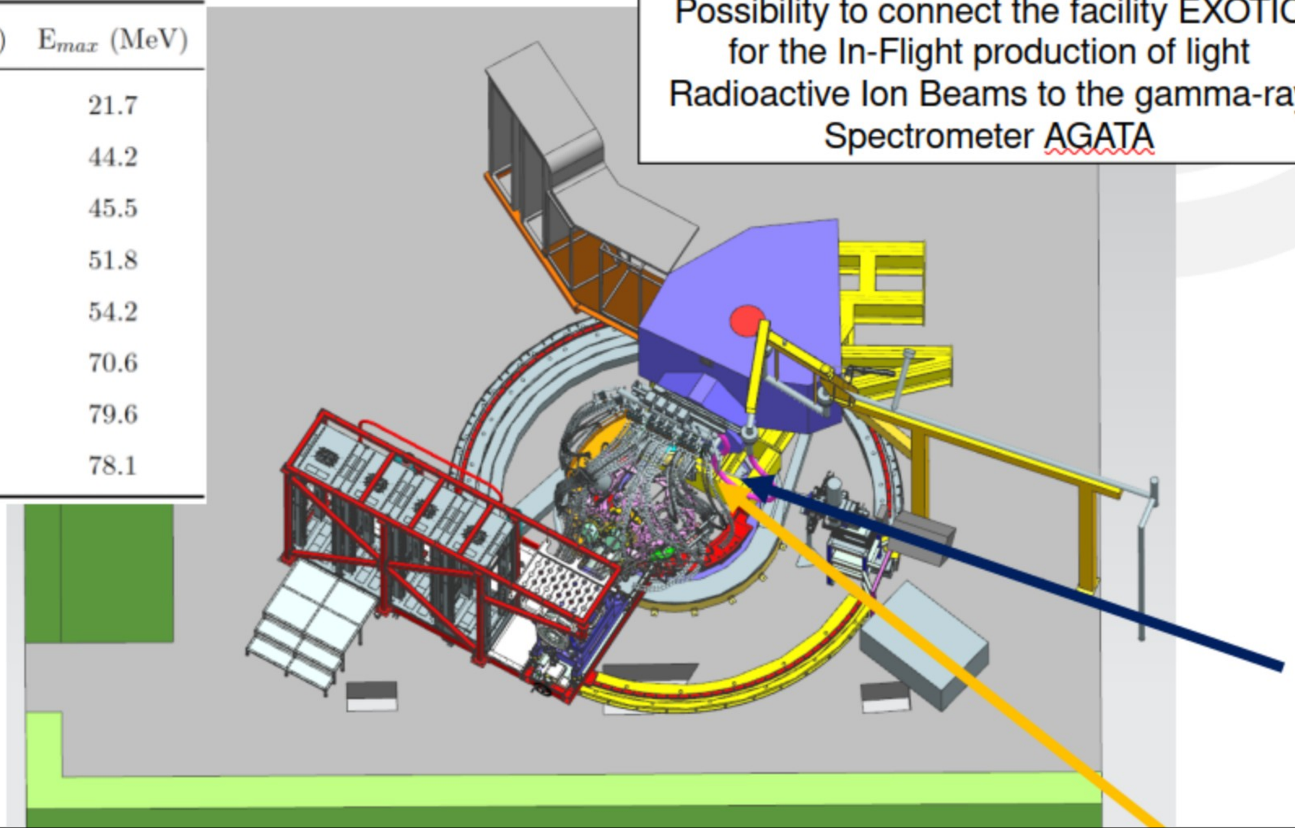
THE NEXT CAMPAIGN: TANDEM + EXOTIC BEAM LINE

RIB	Intensity (pps)	E_{max} (MeV)
$^{8}Li^{3+}$	5×10^4	21.7
$^{7}Be^{4+}$	5×10^5	44.2
$^{8}B^{5+}$	4×10^2	45.5
$^{10}C^{6+}$	2×10^3	51.8
$^{11}C^{6+}$	10^5	54.2
$^{15}O^{8+}$	2×10^4	70.6
$^{17}F^{9+}$	4×10^4	79.6
$^{18}Ne^{10+}$	2×10^3	78.1

Possibility to connect the facility EXOTIC for the In-Flight production of light Radioactive Ion Beams to the gamma-ray Spectrometer AGATA



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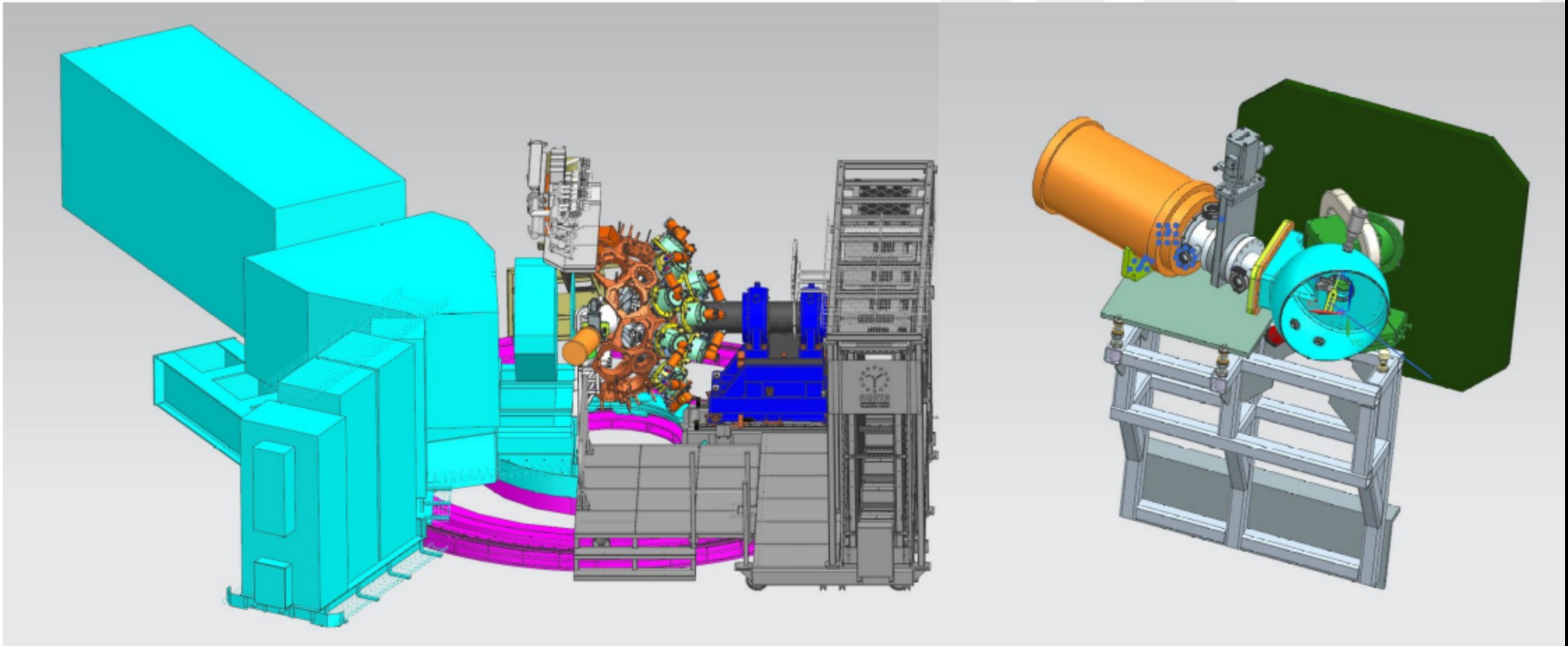
GAMMA
R. Menegazzo

NOSE INTEGRATION



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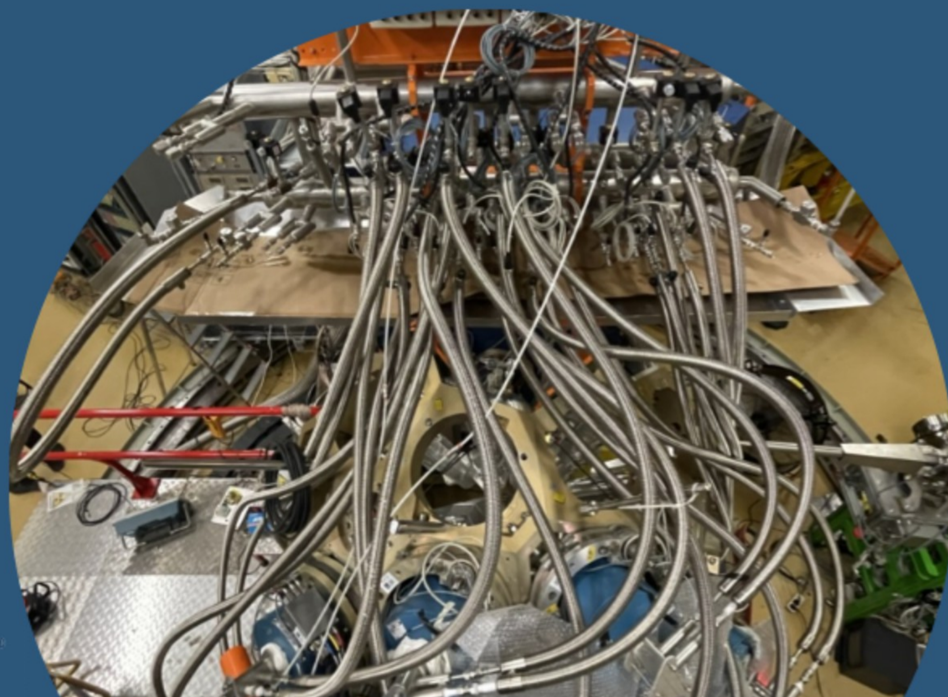
Courtesy of M. Rampazzo

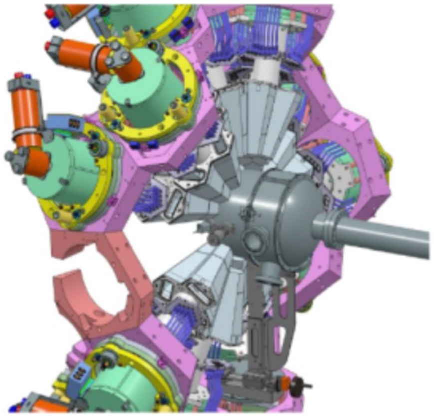
THE ZERO DEGREE CAMPAING

2026-2028

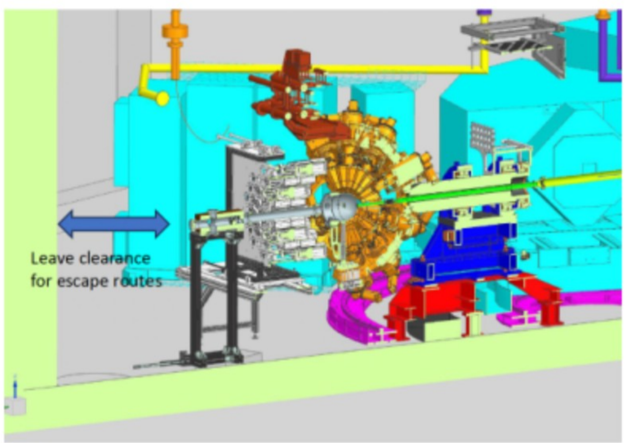


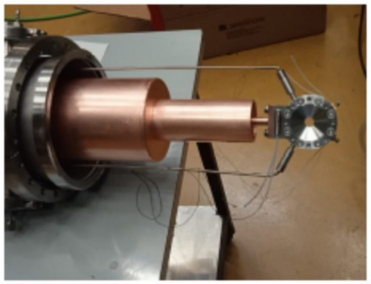
15

STATUS OF THE ZERO DEGREE CAMPAIGN



- Mechanical design have been finalized.
- Production of the new AGATA support has been made.
- All infrastructure (LN2, ...) is finalized
- Production of the new reaction chamber and beam dump is on-going
- Integration of the ancillaries and new target system on-going





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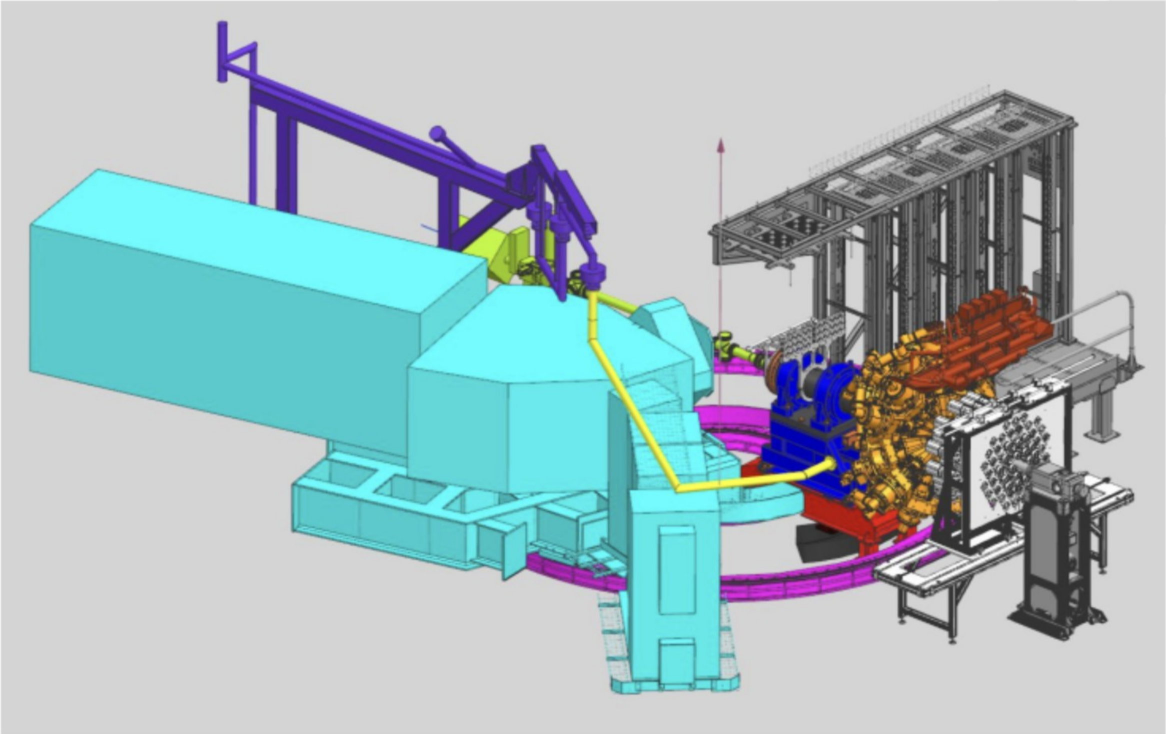
ZERO DEGREE CAMPAIGN "BULKY" ANCILLARIES



NEDA Neutron Detector Array
- 54 liquid scintillator cells
- 50 cm from the target
- Neutron discimination:
  - PSA
  - Time of flight
- Digital electronics compatible with AGATA
- DAQ integration is on-going

INFN Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI LEGNARO

J.J. Valiente Dobón, Nucl. Inst. Meth. A **927** (2019) 81

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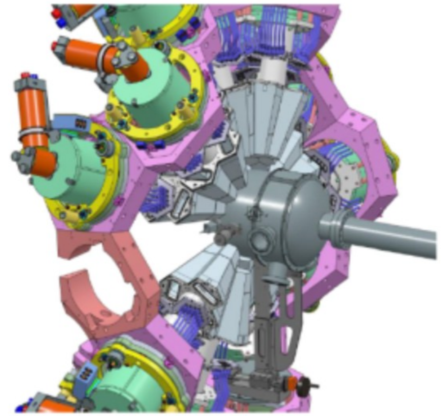
INFN

GAMMA
R. Menegazzo

STATUS OF THE ZERO DEGREE CAMPAIGN



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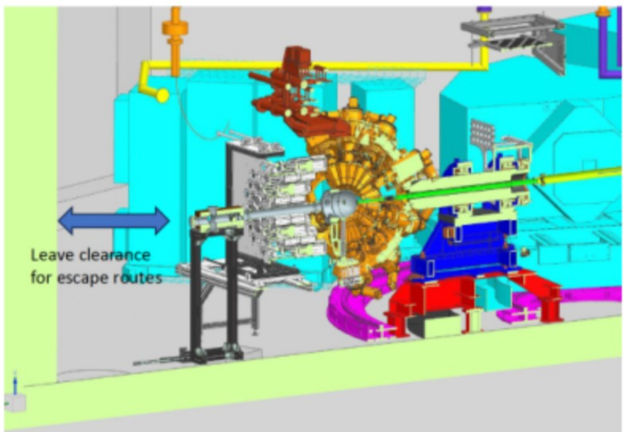
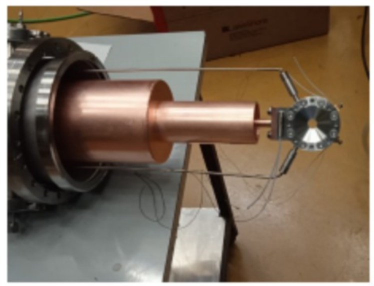
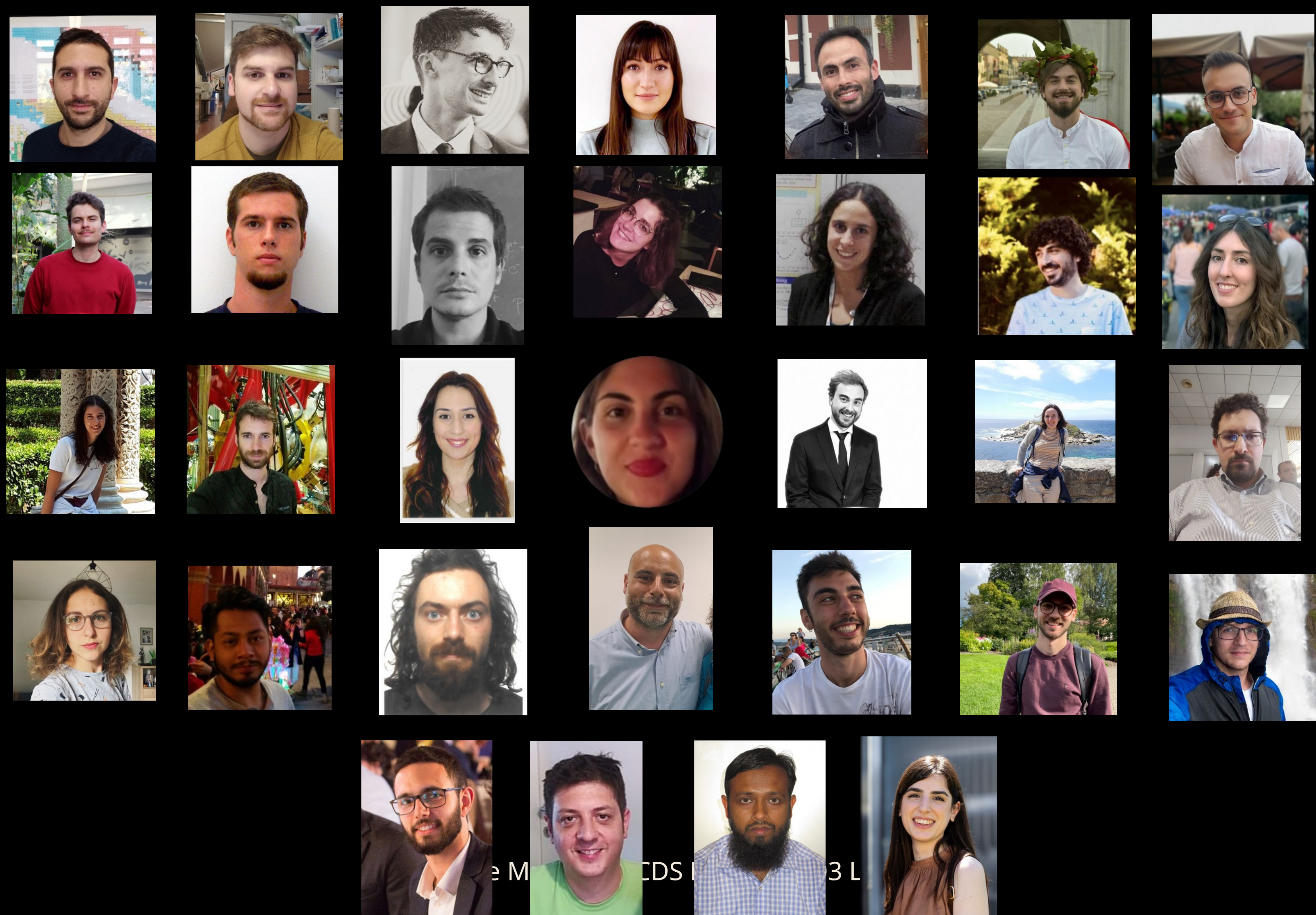
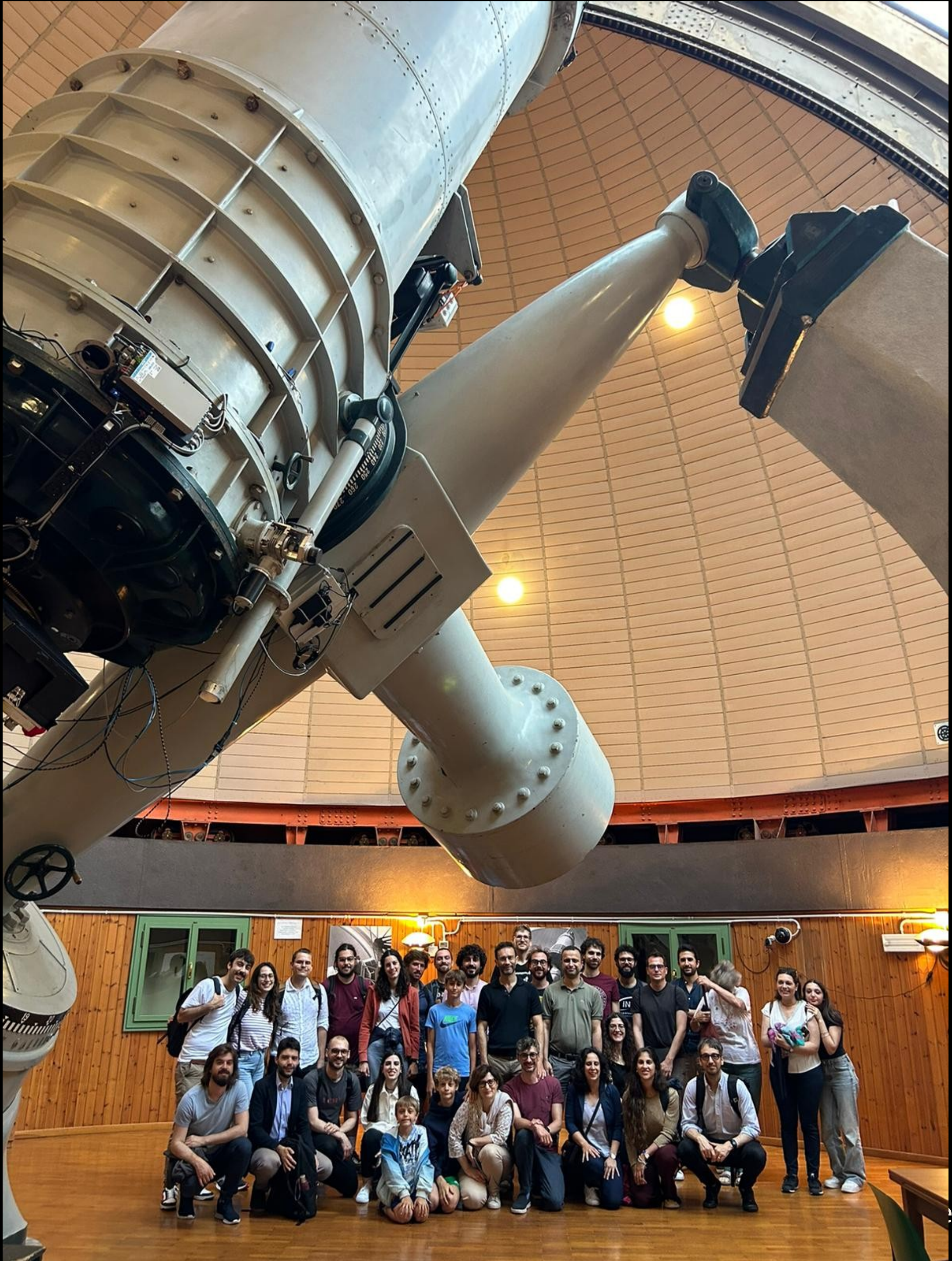




Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI LEGNARO

Babel tower: 10 nationalities



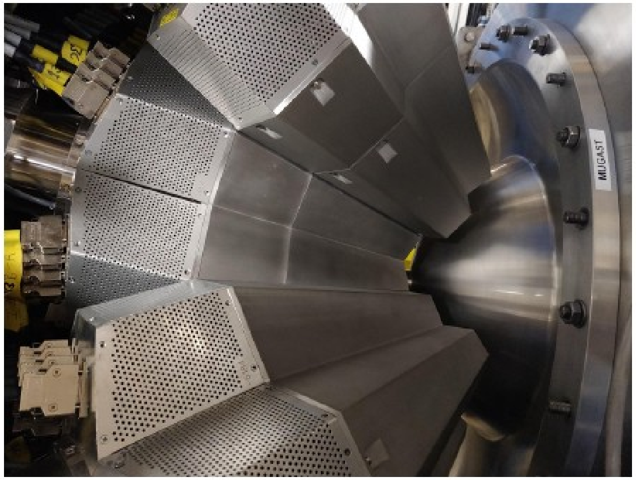
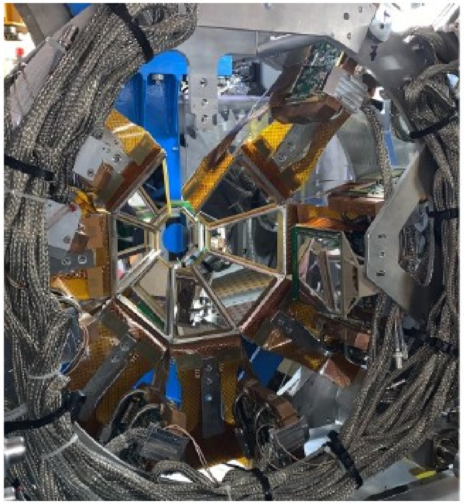
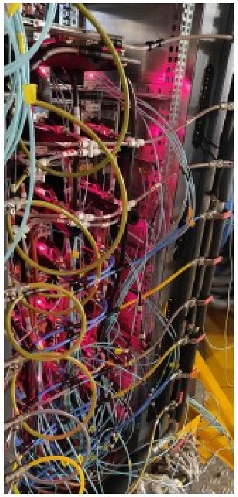
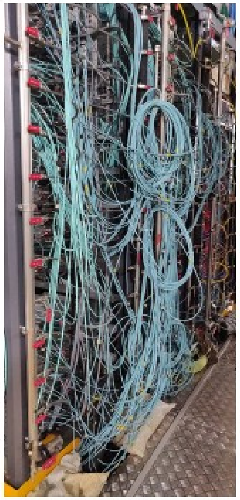


First young
GAMMA meeting

Osservatorio
Asiago

1st AGATA campaign with ISOL beam

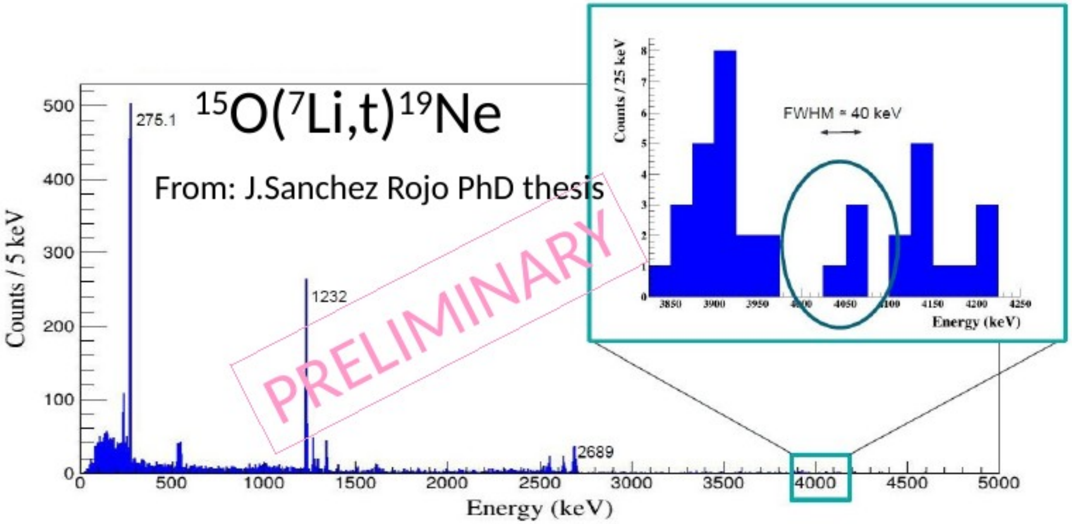
AGATA+MUGAST+VAMOS setup

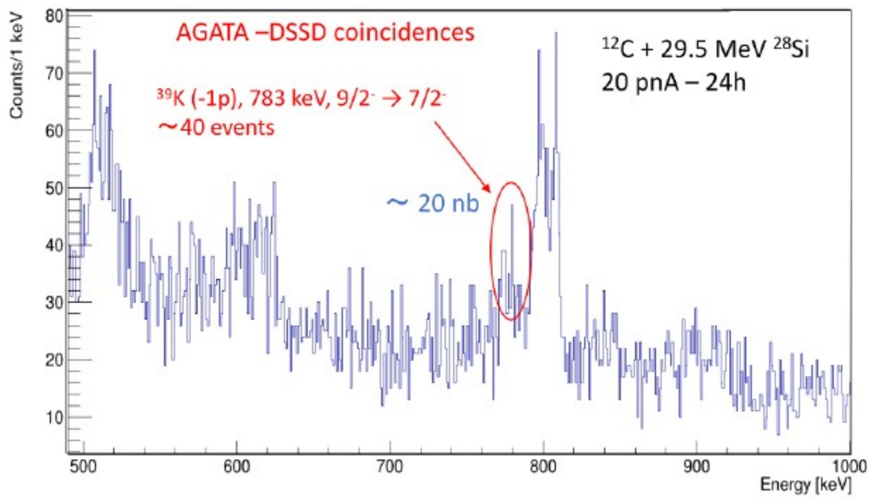

laboratoire commun CEA/DRF CNRS/IN2P3

DM et al. “Advances in nuclear structure via charged particle reaction with AGATA” EPJA 2023
M.Assié et al., “MUGAST-AGATA-VAMOS campaign: setup and performaces” NIMA 2021

Pushing the limit of sensitivity



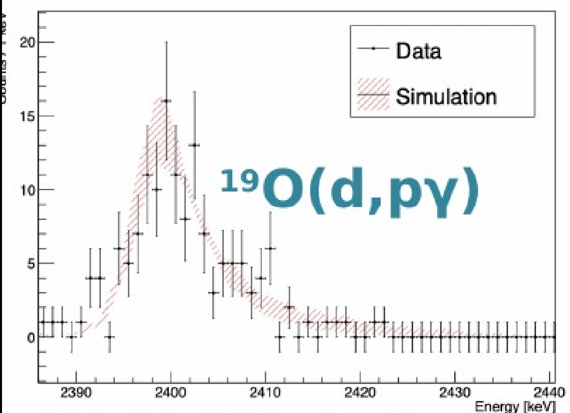
G.Montagnoli at this conference



- $^{15}O(\alpha,\gamma)^{19}Ne \leftarrow {}^{15}O(^7Li,t)^{19}Ne$
- Beam rate : ~10^7pps and triple coincidence: γ+t+^{19}Ne
- Minimum detection limit: **cross section few µb/sr**

Fusion far below the barrier: 12C+28Si
Stable beams, particle-gamma coinc.
Estimated **cross section ~20 nb**

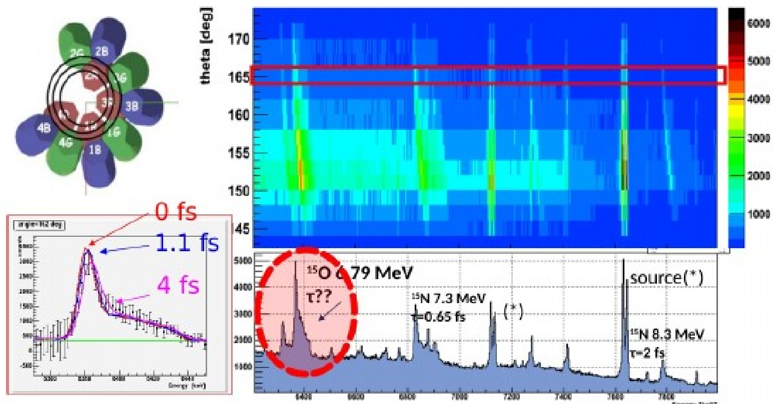
Lifetime arrow



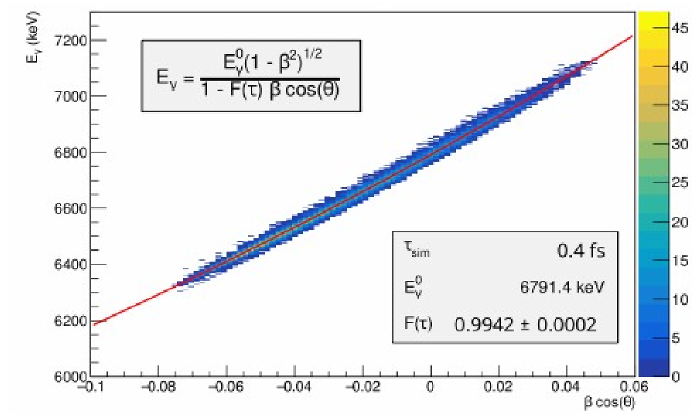
^{19}O (d,p)^{20}O, 3N forces

τ_{2+}: **63^{+29}_{-16} fs**

I.Zanon et al., Phys. Rev. Lett. 131 (2023) 262501



^{14}N(^{2}H,n)^{15}O for CNO cycle
Estimated lifetime **limit <1 fs**
(unpub)
No particle detection



^{16}O(^{3}He,^{4}He)^{15}O for CNO cycle
Estimated lifetime value **<1 fs**
(sim.), particle detection

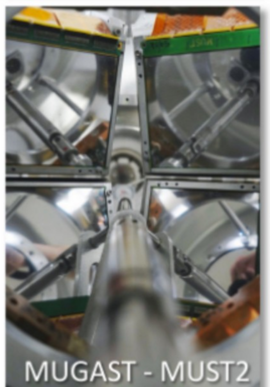
Analysis on-going
RUN LAST November '23

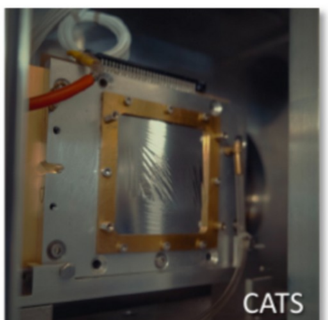
SOCIETÀ ITALIANA DI FISICA

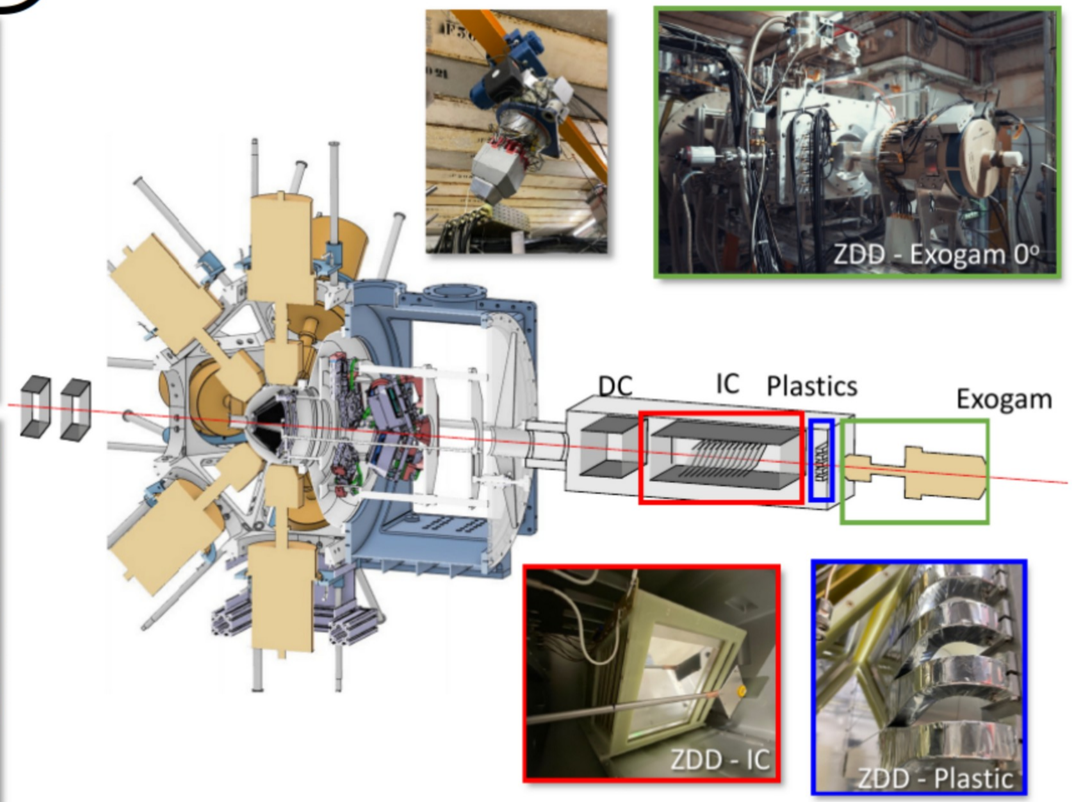
MUGAST@LISE: 2023-2026

Setup:

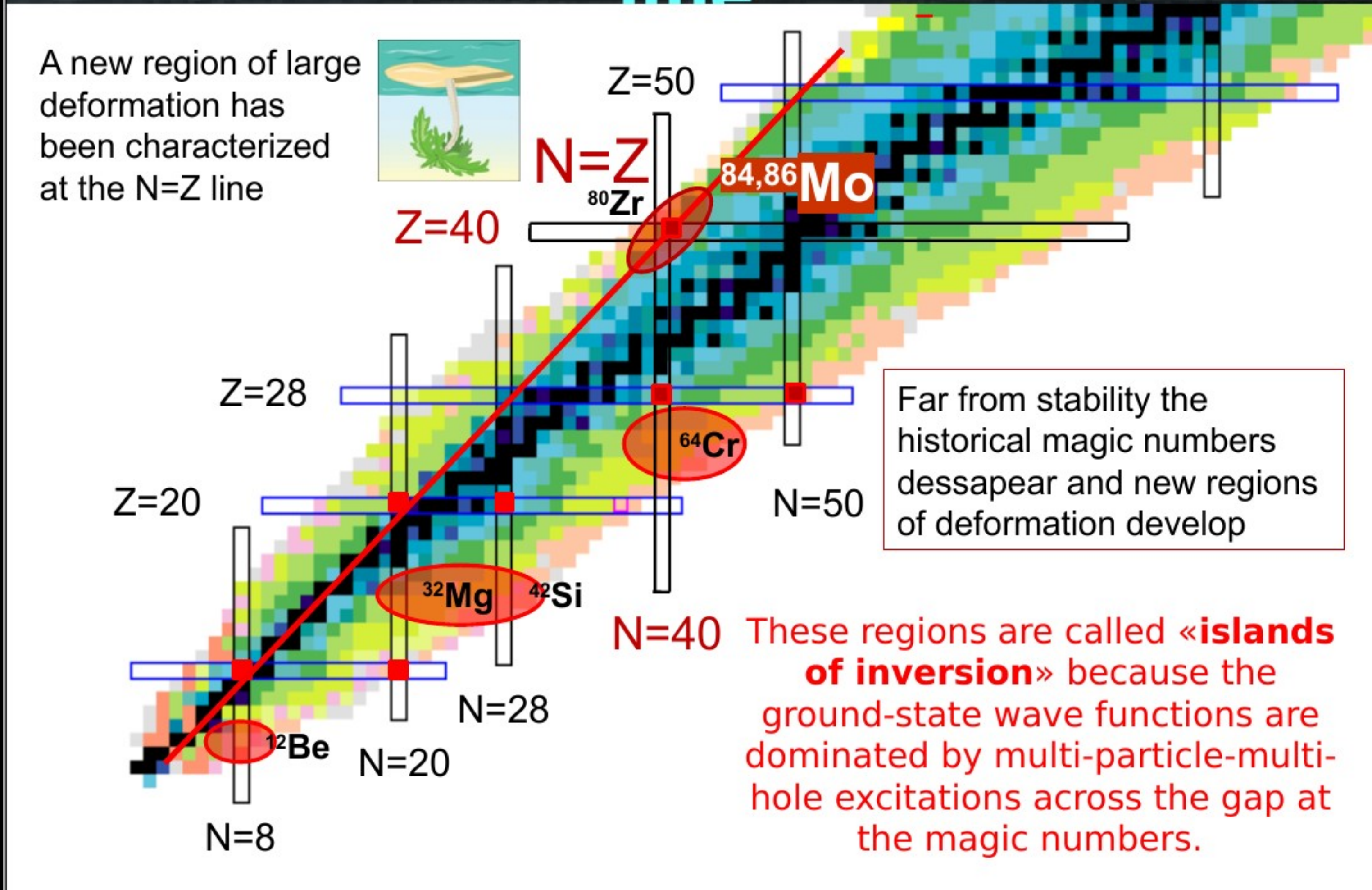
- CATS beam tracker
- 5 trapezoidal DSSD (backward)
- 4 MUST2 telescopes (forward)
    - 300 um DSSSD
    - CsI crystals
- Exogam Ge γ-ray spectrometer
- 0° Detection: ZDD from LISE
    - Drift chamber (DC)
    - Ionization chamber (IC)
    - Plastic detector
    - Exogam







New Island of inversion at the N~Z line



The experiment @NSCL - MSU

Radioactive beam ^{86}Mo at 103 MeV/A

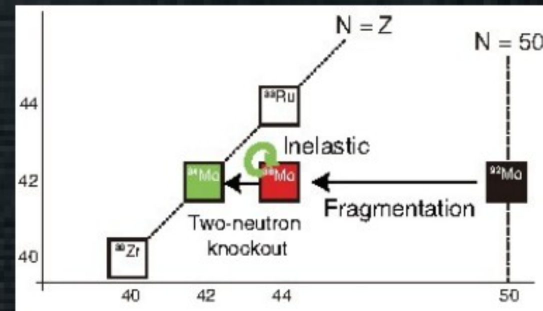
Identification event-by-event
B – Rho, TOF

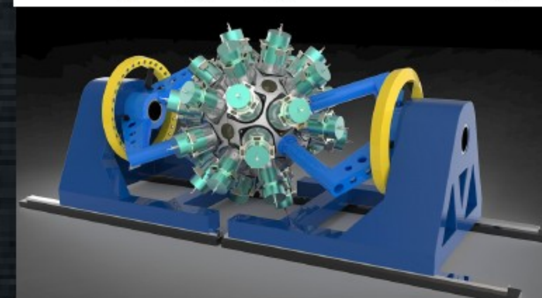
^{84}Mo produced in a 2n-knockout reaction

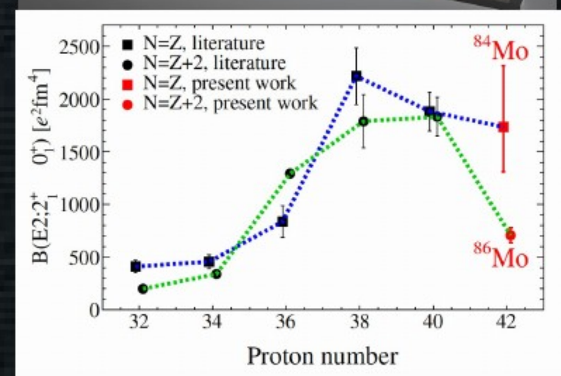
GRETINA : gamma-ray array of 48 HPGe detectors 36-fold segmented each

TRIPLEX plunger → lifetime measurement

Unexpected large deformation in 84Mo N=Z=42, decreassing abruptly with +2n







^{84}Mo

^{86}Mo

Submitted to Nature Physics

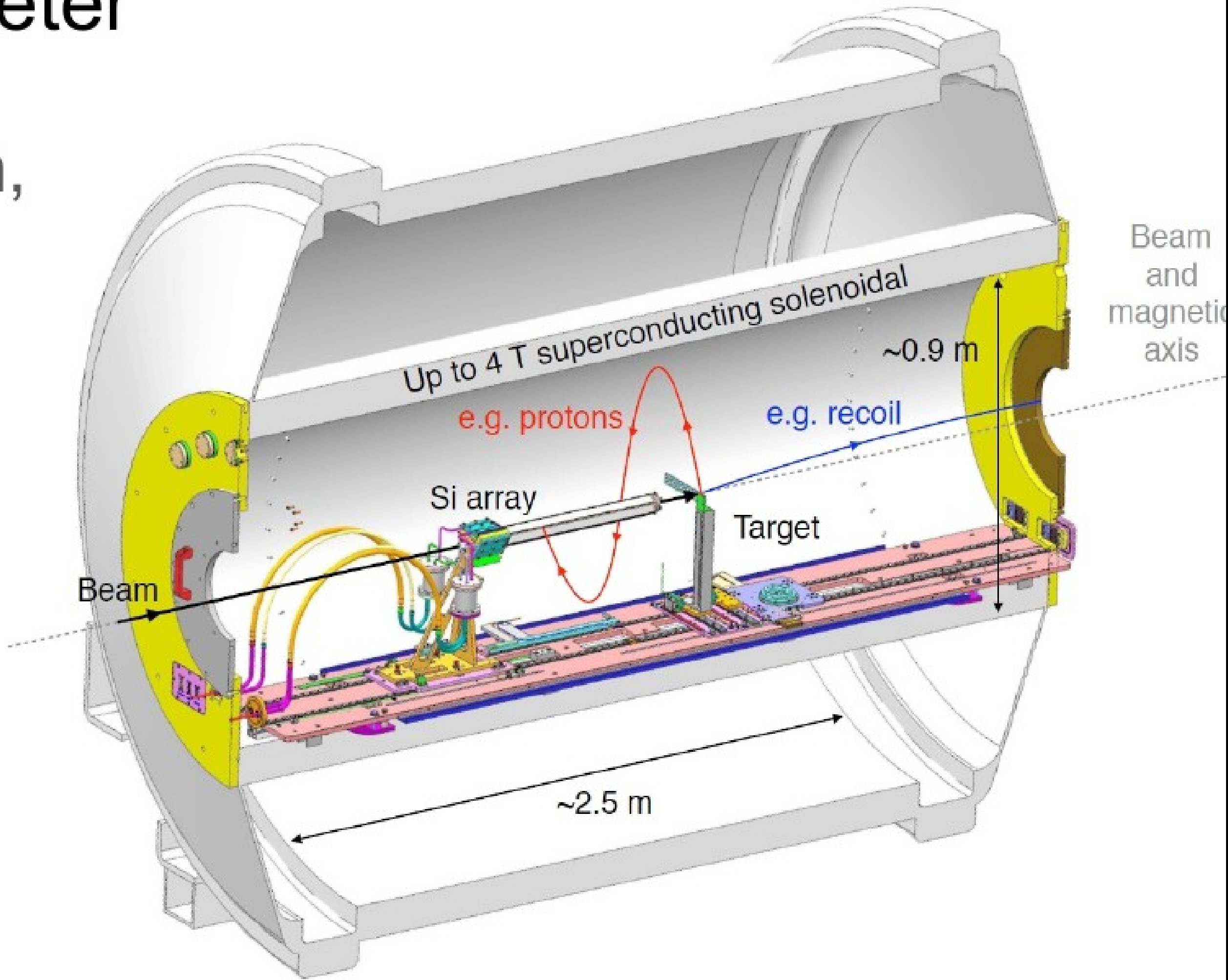
J.Ha, F. Recchia, SM Lenzi et al.

STellar ARcheology with Solenoidal spectrometer

Solenoidal spectrometer

- Simple configuration, few detectors
  - Max 150 acquisition channel
- All commercial solutions

→ **2 MU SPM**



GAMMA
R. Menegazzo

CONTRIBUTO PANDORA

frontiers | Frontiers in Physics

TYPE Original Research
PUBLISHED 07 October 2022
DOI 10.3389/fphy.2022.936081

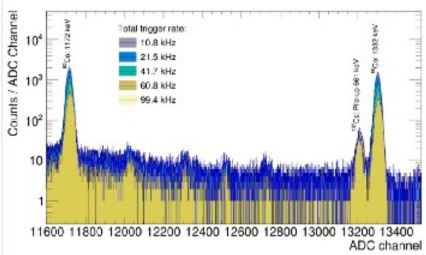


FIGURE 7
Stacked spectra obtained for five different total counting rates. The peak lying close to the 1332-keV line (13220 ADC channels) is due to the pile-up peak of the intense ^{137}Cs source.

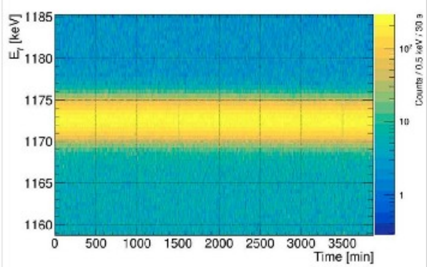


FIGURE 8
Energy vs. Time measured of 60 h using the multi-source with a total rate of 50 kHz. The energy axis has been zoomed on the 1172-keV transition coming from the ^{60}Co source.

Check for updates

OPEN ACCESS

EDITED BY
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United Kingdom

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Institute of Nuclear Research (ATOMKI),
Hungary
Jack Henderson,
University of Surrey, United Kingdom

*CORRESPONDENCE
D. Santonocito,

A high resolution γ-ray array for the pandora plasma trap

A. Goasduff[1], D. Santonocito[2*], R. Menegazzo[3], S. Capra[4,5], A. Pullia[4,5], W. Raniero[1], D. Rosso[1], N. Toniolo[1], L. Zago[1,6], E. Naselli[2] and D. R. Napoli[1]

[1]Laboratori Nazionali di Legnaro, INFN, Legnaro, Italy, [2]Laboratori Nazionali del Sud, INFN, Catania, Italy, [3]Sezione di Padova, INFN, Padova, Italy, [4]Dipartimento di Fisica, Università degli Studi di Milano, Milano, Italy, [5]Sezione di Milano, INFN, Milano, Italy, [6]Dipartimento di Fisica e Astronomia, Università degli Studi di Padova, Padova, Italy

Per 2023:

- Produzione pre-amplificatori (disegno UniMI/INFN MI)
- Test prestazioni ad alto ratre: fino a 100 kHz
- Annealing riv. GASP (da programmare)
- Modifica mother-board GASP (passaggio 12V --> 24V)
- Studente magistrale condivizo tra GAMMA/PANDORA

GAMMA
R. Menegazzo

Zoom meeting referee N3G 28/03/2023

N3G : Next Generation Germanium Gamma Detectors

D. De Salvador[1,2]

Responsabile Nazionale

[1] INFN-LNL
[2] Università di Padova

CALL 2021-2023

Laboratori di Legnaro
D.R. Napoli

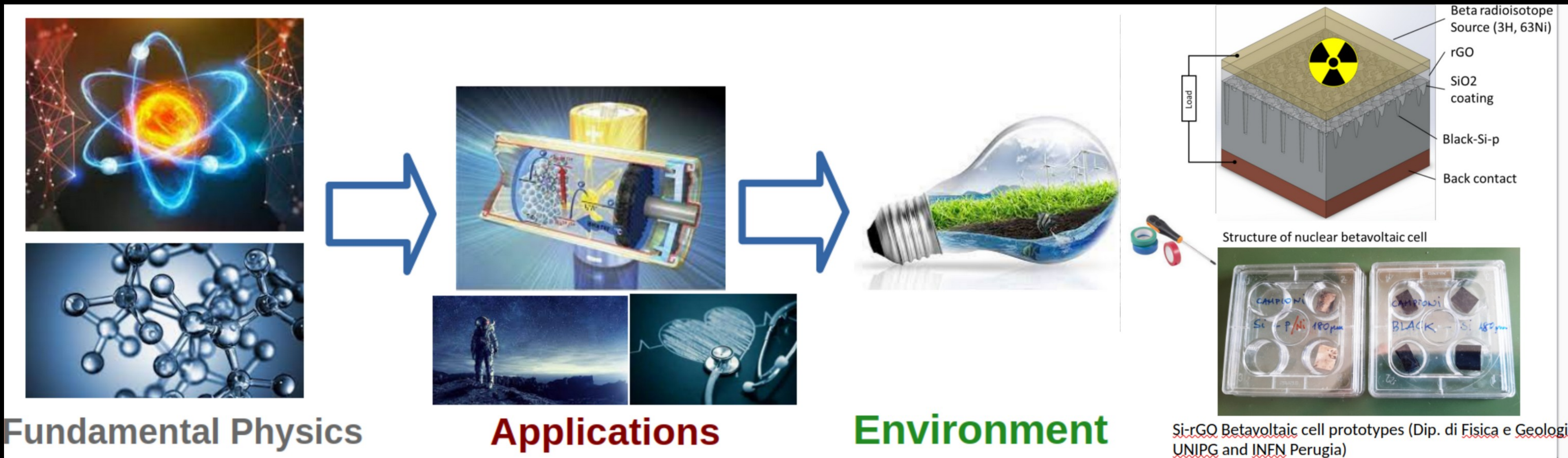
Sezione Milano
S. Capra

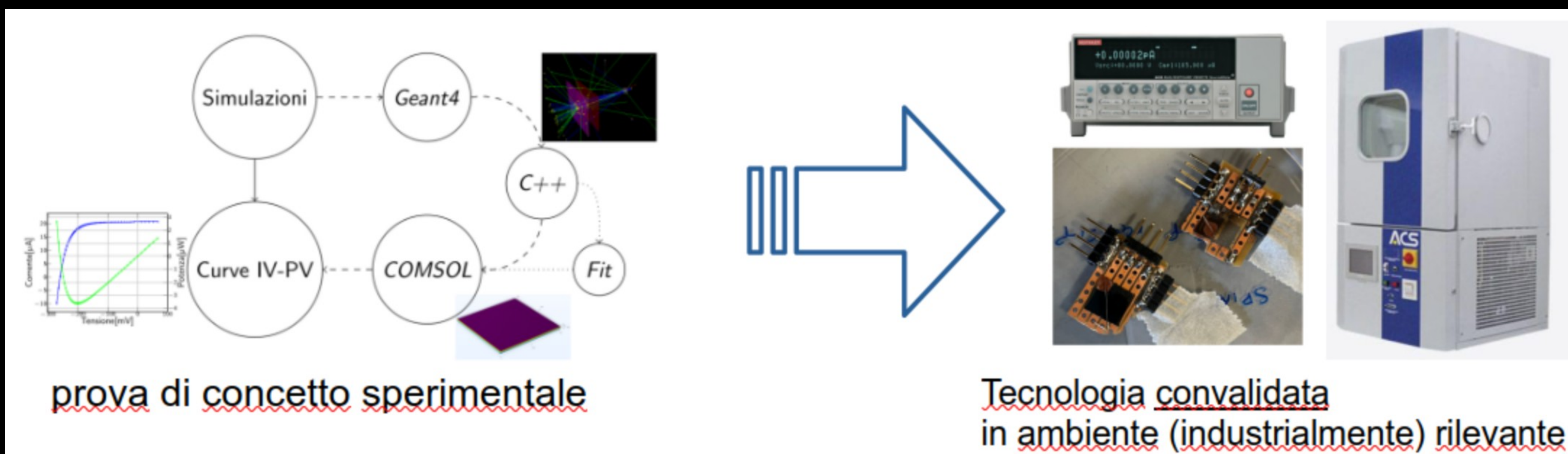
Sezione Ferrara
A.Mazzolari

Sezione Padova
F. Recchia

Commissione trasferimento tecnologico INFN – trattative per accordi con la Mirion

GAMMA
R. Menegazzo





Apparato	Descrizione	Richieste [k€]
AGATA	Meccanica, elettronica ancillari, comp	30
GRIT	MoU	60
Altre spese	Isotopi, consumo e manutenzioni	10
Altre spese	Missioni	100
TOTALE		200

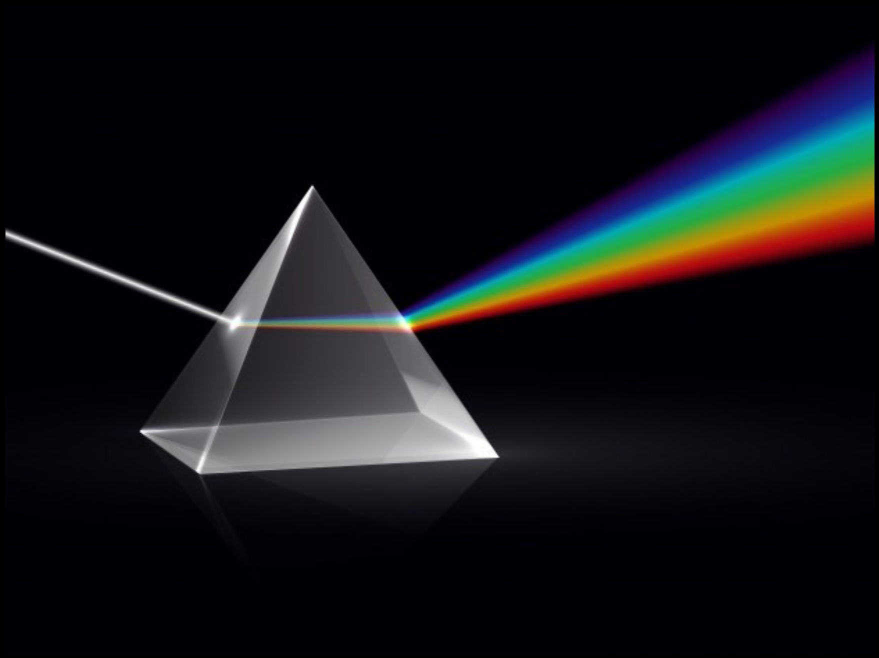
TO BE DISCUSSED

Divisione - Servizio	Attività	Richiesta
STA	test controllo e test Si GRIT	4 mu
STG	Assistenza produzione elettronica ancillari AGATA. Riparazioni elettronica e sviluppo sistemi di controllo B-DS @ SPES. Bonding Sida GRIT	6 mu
UPM	Progettazione componenti meccaniche nuovo setup a 0° AGATA e PRISMA @ LNL. Supporto disegno STARS @ LNL	10 mu
OM	Supporto all'installazione rivelatori e manutenzione componenti meccaniche AGATA @ LNL. Secondo braccio PRISMA	6 + 12* uomo

GAMMA
R. Menegazzo

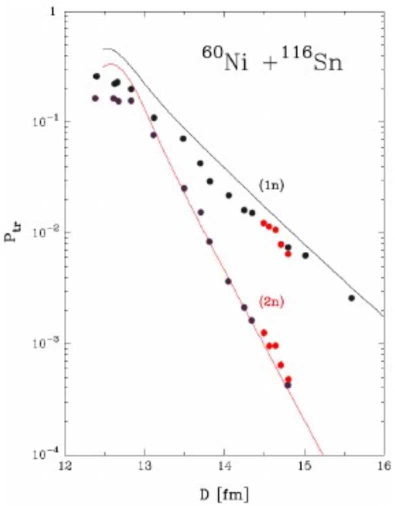
#	#	Nome	Tipo	Qualifica pr	% FTE
	1	Bazzacco Dino	Associato	Affiliato	0
	2	Carollo Sara	Associata	Post-Doc UniPD	100
	3	Francesco Recchia	Associato	Prof. Associato	100
	4	Galtarossa F.	Dipendente	Ricercatore	100
	5	Gongora Benito	Associato	Post-Doc UniPD	100
	6	Lyu Haobao	Associato	PhD	100
	7	Kseniia Rezynkina	Dipendente	Assegnista	100
	8	Lenzi Silvia M.	Associata	Prof. Ordinario	80
	9	Mazzocco Marco	Associato	Prof. Associato	20
	10	Menegazzo Roberto	Dipendente	Primo Ricercatc	70
	11	Mengoni Daniele	Associato	Prof. Associato	100
	12	Montagnoli Giovanna	Associata	Prof. Associato	100
	13	Nicolàs Del Alamo Raquel	Associata	PhD	100
	14	Pellumaj Julgen	Associato	Post-Doc UniPD	100
	15	Pigliapoco Sara	Associata	Post-Doc UniPD	100
	16	Pilotto Elia	Associato	PhD	100
	17	Ronning Eleanor	Dipendente	Ricercatore stra	100
	18	Simioni Federico	Associato	PhD	100
	19	Scarlassara Fernando	Associato	Ricercatore	100
				Ricercatori	1670

PRISMA-FIDES → GAMMA

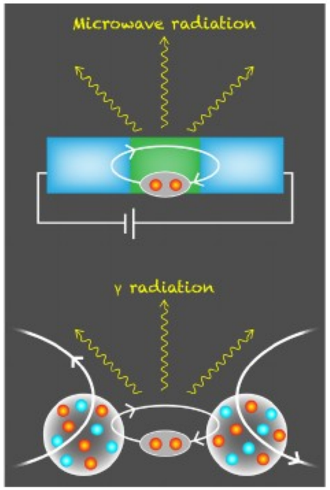


Colliding nuclei: Josephson junction?

A new analysis of heavy-ion collision experiments uncovers evidence that two colliding nuclei behave like a Josephson junction, in which Cooper pairs tunnel through a barrier between two superfluids.



D.Montanari, et al., PRL113(2014)052501;
and PRC93(2016)054623



Physics Viewpoint:

- Tiniest superfluid circuit in nature
- Superconductivity valid for macroscopic phenomena in solids may be applicable to the much smaller scale (femtometer nuclear scale)
- Pairing description is appropriate for a small number of particles

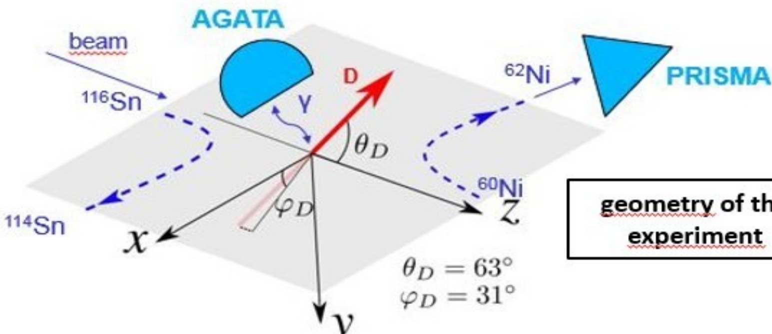
G. Potel, F. Barranco, E. Vigezzi, and R. A. Broglia, Phys. Rev. C 103, L021601 (2021)

result from AGATA demo+PRISMA exp in 2011
AGATA campaign at LNL is awaited soon

COMING SOON!

PRISMA-FIDES
G. Montagnoli

Search for a nuclear Josephson effect - PRISMA-AGATA experiment Feb. 2023

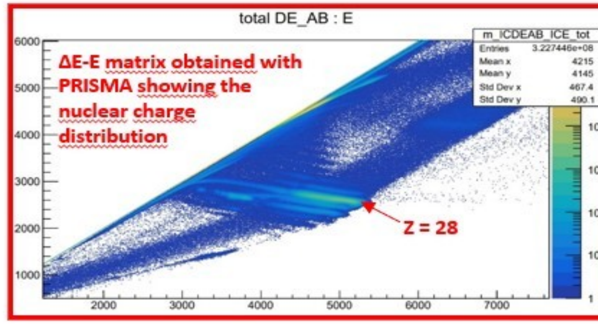


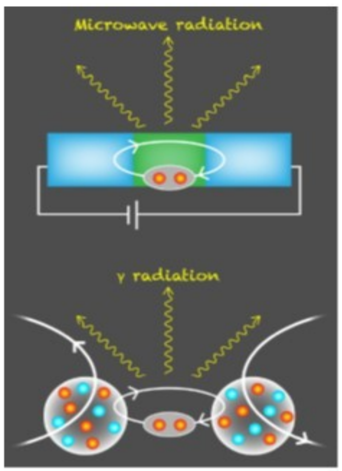
^{116}Sn beam PIAVE+ALPI, E_{lab} = 452.5 MeV, I = 3 pnA
target thickness 300 μg/cm2, Prisma θ_{lab} = 20°

geometry of the experiment

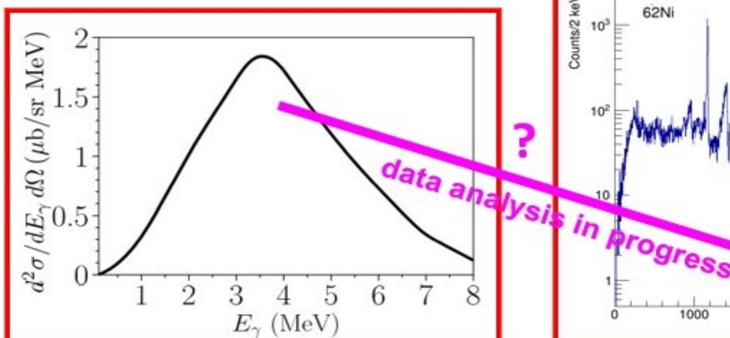
examples of preliminary data

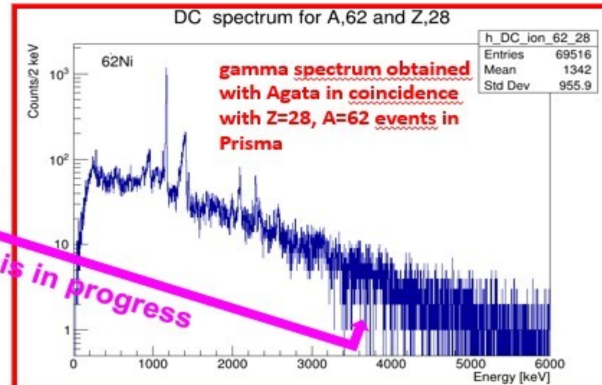
A first challenging experiment has been carried out at LNL looking at the possible existence of a gamma radiation emitted via a **dipole oscillation D** generated by the two neutron transfer process in the ^{116}Sn+^{60}Ni reaction at energies below the Coulomb barrier. This would evidence that two colliding nuclei behave like a Josephson junction, a device in which **Cooper pairs tunnel through a barrier between two superfluids**





gamma ray strength function predicted by Broglia et al.





Data taken at INFN – Laboratori Nazionali di Legnaro   Spokespersons L.Corradi, S.Szilner

ASFIN2

ASFIN2 (45 ricercatori, 28.37 FTE)

LNS (19.20 FTE) + NA (3.0 FTE) + PG (2.3 FTE) + PD (3.1 FTE):

M. Mazzocco (0.8), S. Pigliapoco (1.0), F. Soramel (0.3), *A. Togni (1.0)*, YanSong Wu (1.0)

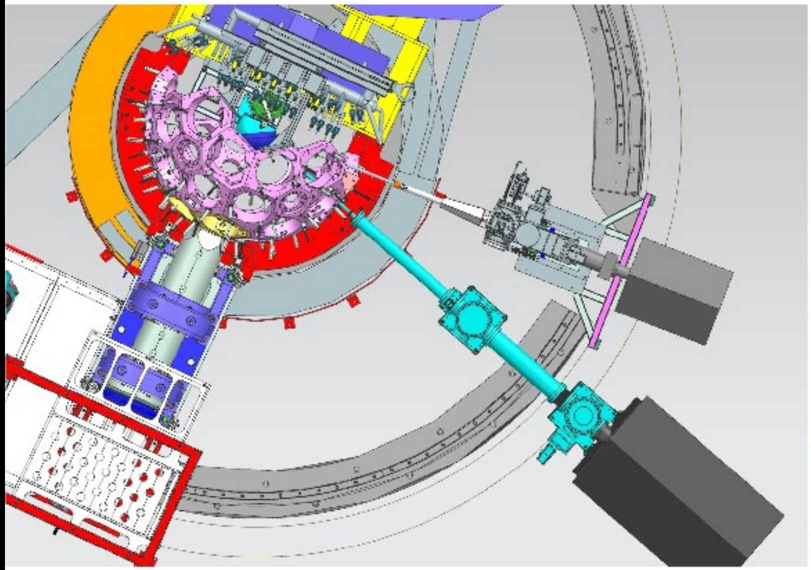
Studio delle reazioni nucleari di interesse astrofisico mediante i metodi indiretti

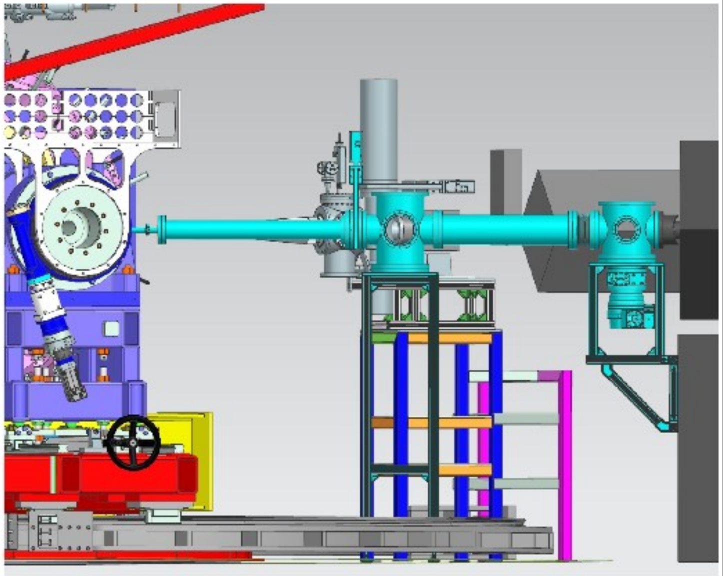
La reazione di interesse astrofisico **x+A → c+d** viene studiata mediante la reazione Cavallo di Troia **a+A → c+d+s**, nell'ipotesi che a abbia una pronunciata struttura a cluster **a = x+s** ed **s** rimanga **spettatore** durante l'interazione.

ASFIN2
M. Mazzocco

ASFIN2_PD: Highlights Attività 2022-23

Connection Beam-Line between EXOTIC and AGATA



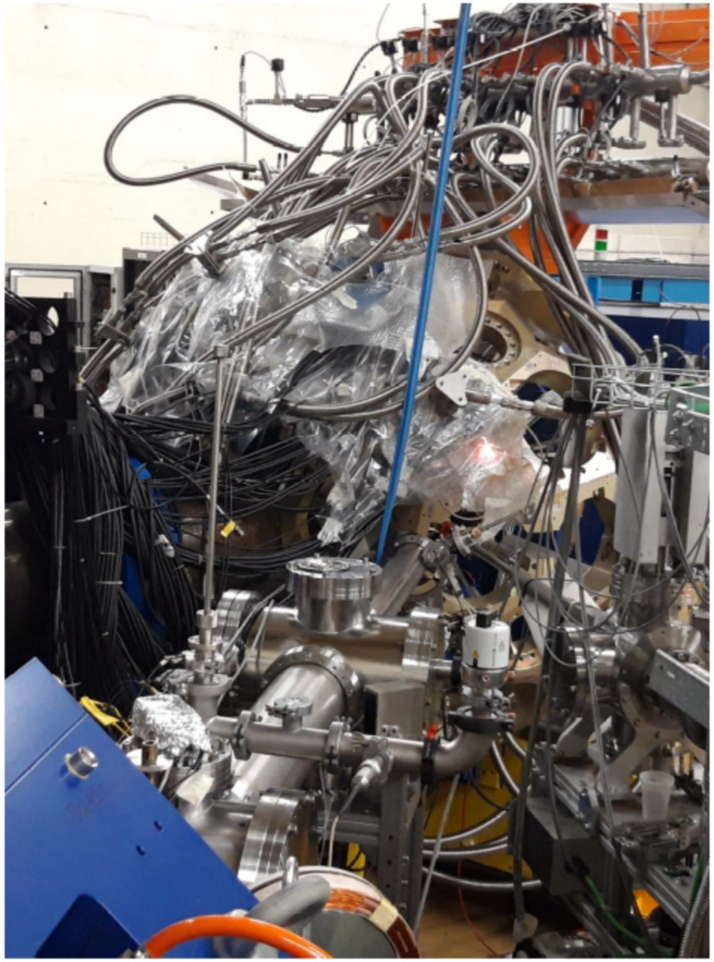


Ufficio Tecnico – INFN Padova

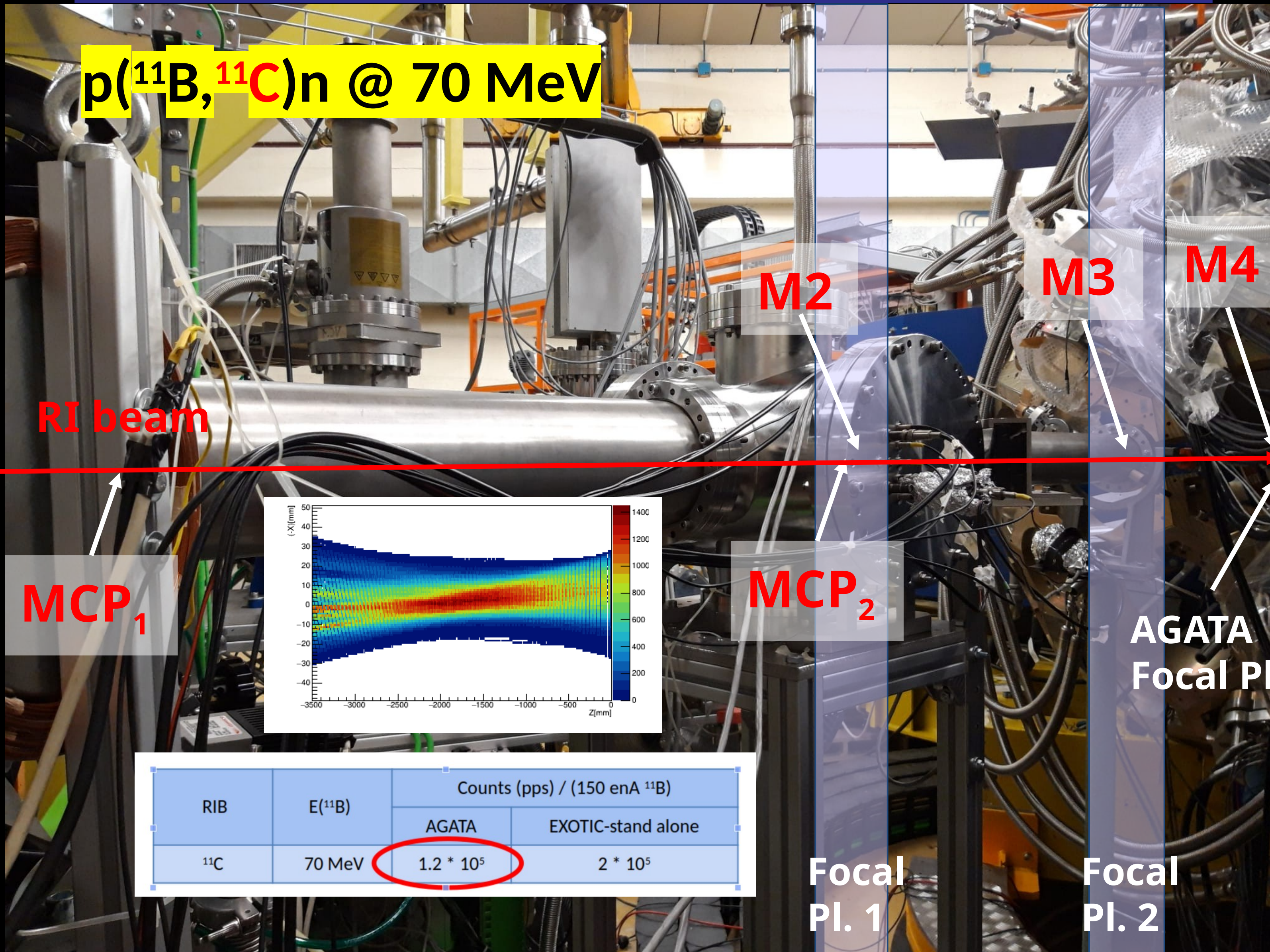
ASFIN2_PD: Highlights Attività 2024-25

Time-Line of EXOTIC-AGATA

November-December 2023: Developement of the 1st **Micro-Channel Plate** (MCP) detector.
May-June 2024: Installation of the second chamber with the 2nd MCP.
July 2024: First test of the 2 MCPs together.
September 2024: beamline lifted (+14 mm).
November 2024: extended the beamline 1m downstream.
December 2024: connection to AGATA for the first time.
January 2025: laser track alignment of the entire beamline.

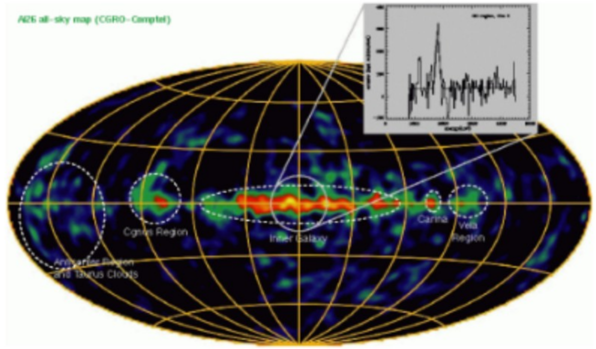


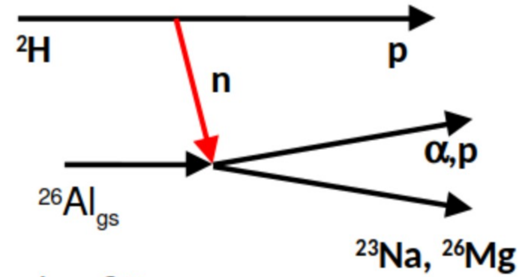
6th Commissioning Run (Apr. 12-17, 2025)



RIB	E(^{11}B)	Counts (pps) / (150 enA ^{11}B)	
		AGATA	EXOTIC-stand alone
^{11}C	70 MeV	1.2 * 10^5	2 * 10^5

$^{26}Al(n,p)^{26}Mg$ and $^{26}Al(n,\alpha)^{23}Na$ by THM @TRIUMFJuly 2024

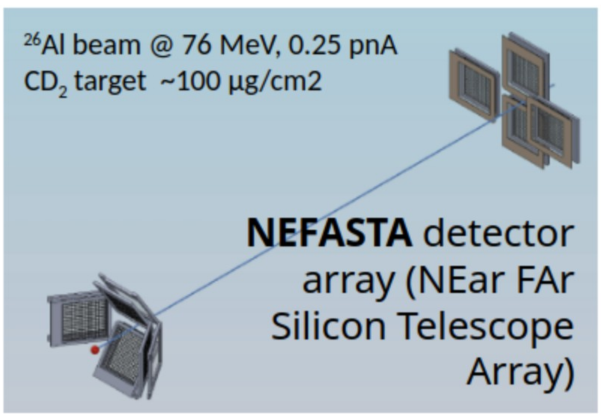


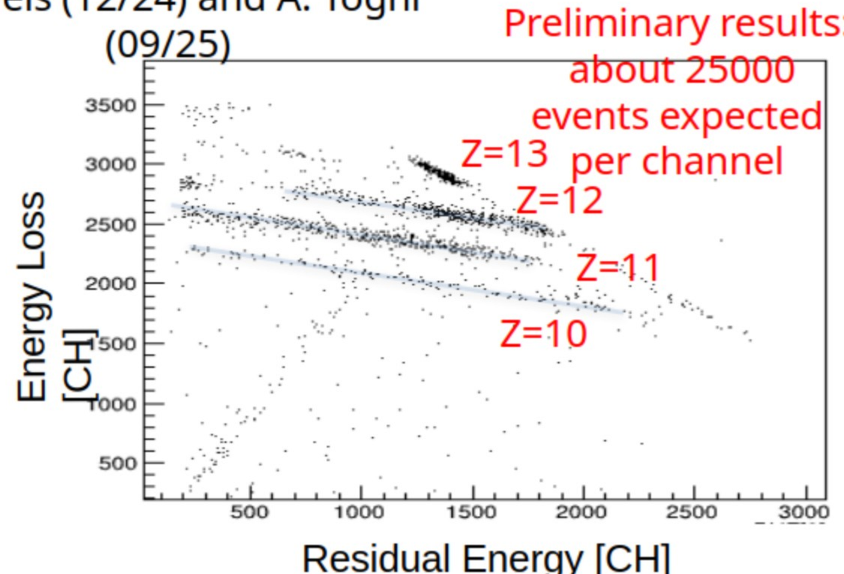


$^{2}H(^{26}Al_{gs},p\ ^{26}Mg)p$

$^{2}H(^{26}Al_{gs},\alpha\ ^{23}Na)p$

PD: Master Thesis of F. Andreis (12/24) and A. Togni (09/25)



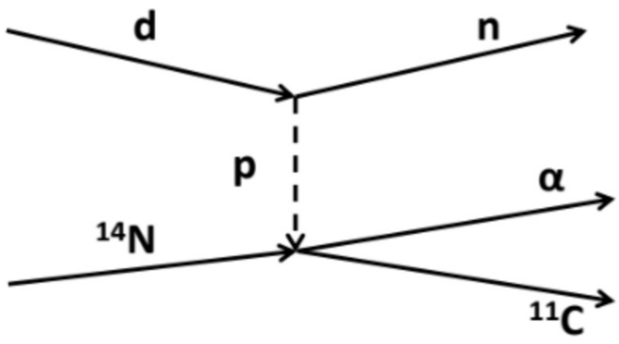


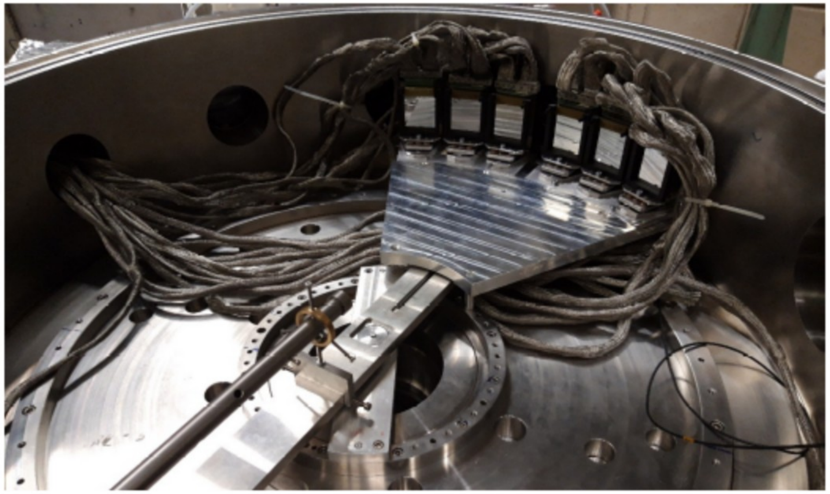
$^{14}N(p,\alpha)^{11}C$ (July 4-15, 2025) at INFN-LNL

Neutrino induced nucleosynthesis (ν-process) has been addressed as important contributor to the cosmic abundance of light (^{7}Li, ^{7}Be, ^{11}B...) and heavy (^{92}Nb, ^{98}Tc...) nuclei (Ko ApJ2022, Yoshida PRL2006, Mathews&Kajino PRD2012).

Latest calculation (Kajino, Kusakabe, Yao) shows that much **^{11}C** is produced in the ν-process and affects the **final ^{11}B abundance**. We need **a precise knowledge of the nuclear reactions around ^{11}C.**

$^{11}C(\alpha,p)^{14}N$ has a large uncertainty and possibly the most affective to the A=11 abundance among 91 reactions. Direct measurements cannot access the Gamow energy window at about 300 keV. To by the use of ^{11}C RIB, we propose the **Trojan Horse Method (THM) for studying the reverse $^{14}N(p,\alpha)^{11}C$ reaction at INFN-LNL.**





Richieste Finanziarie e Richieste ai Servizi PD

Richieste Finanziare – ASFIN2 Sez. Padova

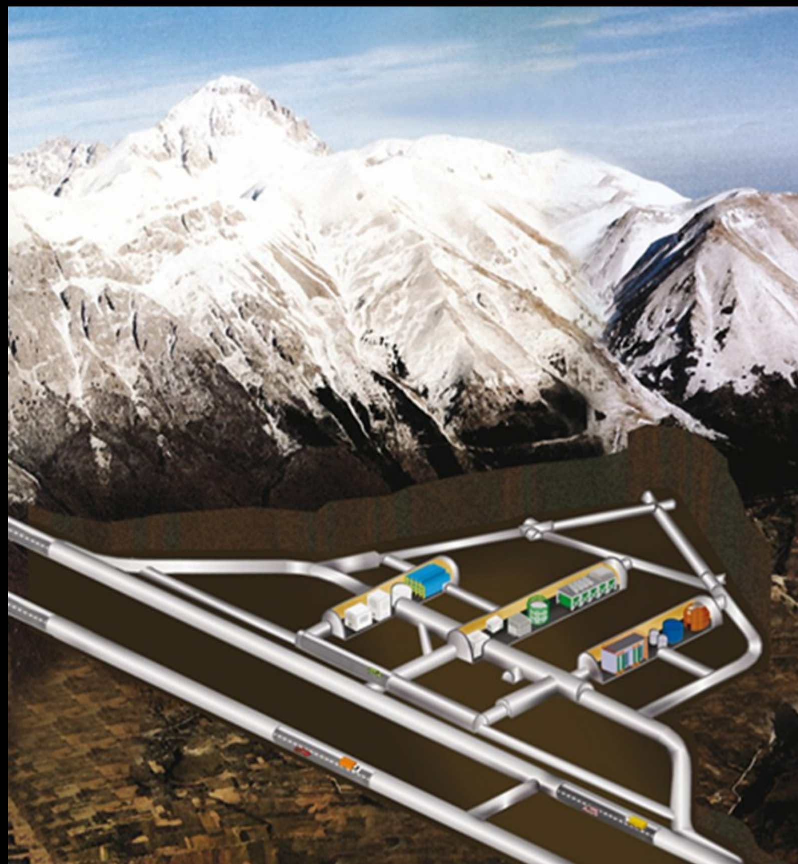
Missioni: ***23.5 k€ (esp. LNL, TAMU, RIKEN, ELI-NP, LNS, HIGS)***
Consumo: ***2 k€ (target)***
Costruzione Apparati: ***20-25 k€ (manutenzione linea EXOTIC)***
Totale:

PRELIMINARY

Richieste ai Servizi della Sezione INFN di Padova

Officina Meccanica: **2 mese/uomo** (piccole lavorazioni delle parti meccaniche necessarie per la campagna sperimentale EXOTIC-AGATA).
Progettazione Meccanica: **1 mese/uomo** (progettazione di piccole componenti meccaniche per la campagna sperimentale EXOTIC-AGATA)
Progettazione Elettronica: **1 mese/uomo** (realizzazione/sistemazione eventuale di piccoli componenti/moduli elettronici, montaggio di ulteriori schede per il readout dei MCP)

LUNA3



GRUPPO LUNA3

C. Broggini (30%), A. Caciolli (100%), R. Menegazzo (30%), Denise Piatti (70%), Jakub Skowronski (100%), R. Biasissi (PhD 100%) – 4.3 FTE

PAPER LUNA NELL'ULTIMO ANNO

- **Skowronski** et al., Phys. Rev. C 111, 064611 (2025) (**Piatti** Corr. Author)
- Masha et al., Eur. Phys. Journal A 61, 45 (2025)
- **Skowronski** et al., Phys. Rev. C 111, 035802 (2025) (**Caciolli** Corr. Author)
- Rapagnani et al., Phys. Rev. C 111, 025805 (2025)
- Campostrini, Imbriani, Masha, **Piatti**, Rapagnani, EPJ Special Topics 233 (19), 015802 (2025)
- Takacs, Ferraro, **Piatti** et al., Phys Rev. C 109, 064627 (2024) (**Piatti** Corr. Author)
- Gesuè, Ciani, **Piatti** et al., Phys. Rev. Lett. 133, 052701 (2024) (**Piatti** Corr. Author)
- Stockel, **Mozumdar** et al., Phys. Rev. C 110, L032801 (2024)
- Ambrosino et al., Scientific Reports 14, 1224 (2024)
- Csedreki et al., J. Phys. G 51, 105201 (2024)
- Pilotto et al., EPJA 61, 117 (2025) (**Skowronski** Corr. Author)
- Gesué, **Turkat** et al., accepted in J. Phys. G (**Turkat** Corr. Author)
- Linkowski, Sidhu, **Skowronski** et al., accepted in EPJA
- deBoer et al., accepted in Phys. Rev. C
- Acharya et al., accepted in Reviews of Modern Physics (SOLAR FUSION 3)
- Chillery et al., accepted to J. Phys. G.
- Sidhu et al., submitted to Phys Rev C
- **Biasissi** et al., in preparation for EPJA
- Spartà R. et al., submitted to EPJ A (CHETEC-INFRA paper)
- Gesué R. et al., in preparation for EPJ A (**Piatti** Corr. Author)
- **Skowronski** et al., in preparation for PRC

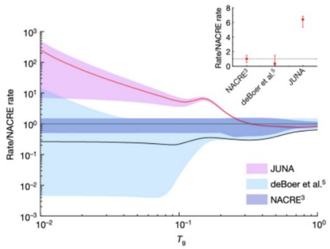
The relevance of the Padova group in the LUNA collaboration is confirmed also this year by covering apical roles in more than 50% of the LUNA papers published and in preparation. This has been a trend for at least the last three years.

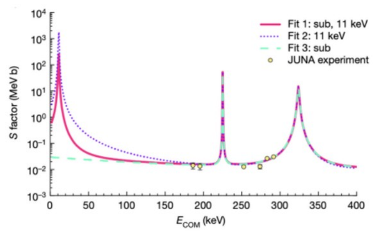
A. Caciolli | LUNA3 Gruppo PD

PRINCIPALI ATTIVITÀ LUNA-PD 2025-2026 AT 400KV

LUNA

Proton capture on 19F





The rate of the $^{19}F(p,\gamma)^{20}Ne$ reaction can challenge, depending on its value, the traditional view that the bulk abundances of elements heavier than fluorine are only produced in late burning stages

Recent results by JUNA reporting a rate higher by a factor of 7 more than literature

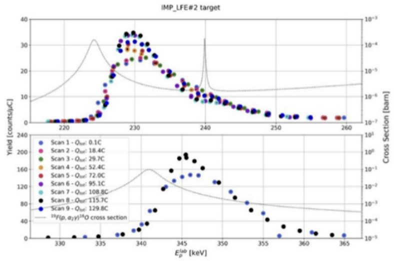
Goals: overlap and extend to low energies the JUNA results

LUNA-PD is coordinating the reaction study (**Skowronski**) and doing the whole analysis (**Biasissi**)

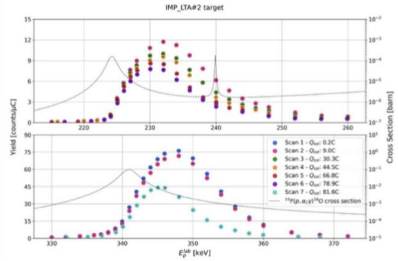
- We have already performed two data taking and a third one is expected for november 2025
- Four different types of targets were tested with high success and the yield measurement has been done in the whole LUNA range.
- Information on branching ratios for the resonances have been obtained thanks to innovative analysis

Preliminary Results -

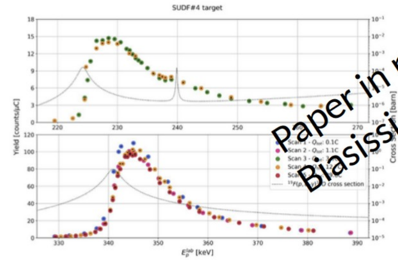
<u>F implanted in Fe:</u>
- Stable up to 130 C .
- Degradation: -20% in plateau height and -1keV in thickness.



<u>F implanted in Ta:</u>
- Stable up to 80 C.
- Degradation: -50% and -5 keV.
- 3 times lower yield w.r.t. F/Fe.



<u>Fluorinated target:</u>
- Thinnest target produced.
- Pretty stable up to 30 C.
- Yield comparable with F/Ta.



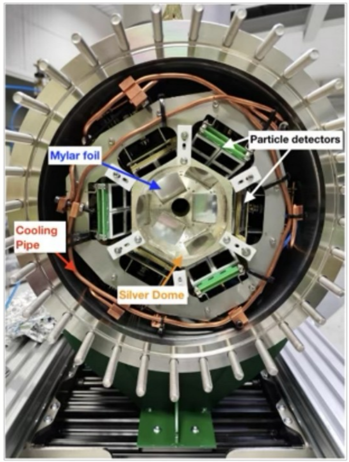
Paper in preparation
Biasissi, Skowronski et al.,

LUNA
A. Caciolli

A. Caciolli | LUNA3 Gruppo PD

FUTURE ATTIVITÀ LUNA-PD 2026-2028 + 2029-2030 AT 400KV

LOI presented for the next five years at LUNA400

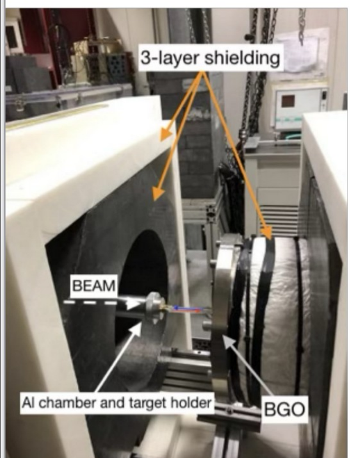


+ HPGe at 0°
(for coincidences and target characterization)

Under LUNA-PD coordination

Table 1: High priority reaction studies proposed at LUNA-400kV accelerator, with the relevant energy range, the expected beam time, the setup to be used and the astrophysical scenario of interest (see text for more details). The required beam time includes an additional 20% of contingency.
* = this measurement will be concurrent with the $^{27}Al(p,\alpha)^{24}Mg$ reaction investigation.
** = a complementary study of the (p,α_π) channel via particle detection is foreseen together with the $(p,\alpha\gamma)$ reaction, see text for details.

Reaction	E_{lab}[1] [keV]	E_{cm} [keV]	Duration [months]	Setup	Scenario
$^{27}Al(p,\alpha)^{24}Mg$	75-400	73-392	2.5	Si array + HPGe	GC anomalies
$^{27}Al(p,\gamma)^{28}Si$	80 - 400	77 - 338	*	Si array + HPGe	Galactic chem. evol.
$^{19}F(p,\alpha_0)^{16}O$	100-400	95-380	5.5	Si array	Pop III stars
$^{19}F(p,\alpha_\pi)^{16}O$	150-400	140-380	4.5**	BGO**	Pop III stars
$^{19}F(p,\alpha\gamma)^{16}O$	133 - 317	127-332	4.5	Si array + HPGe	Pop III stars
$^{28}Si(p,\gamma)^{29}P$	370	357	3.5	HPGe	Novae and SN
	50 - 400	48 - 386	3.5	BGO	Novae and SN
$^{29}Si(p,\gamma)^{30}P$	306; 324;	296; 313;	3.5	HPGe	Novae and SN
	50 - 400	48 - 387	3.5	BGO	Novae and SN
$^{30}Si(p,\gamma)^{31}P$	154.2	149.2	5	BGO	GC anomalies
Total Time			36		



BGO in activation mode to detect 511 keV γ-rays from e^+ annihilation

Table 2: Medium priority reaction studies proposed for the LUNA-400kV accelerator, with the relevant energy range, the expected beam time, the setup to be used and the astrophysical scenario of interest (see text for more details). The required beam time includes an additional 20% of contingency.

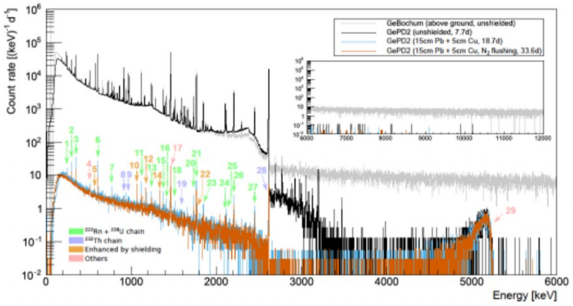
Reaction	E_{lab} [keV]	E_{cm} [keV]	Duration [months]	Setup	Scenario
$^{15}N(p,\alpha)^{12}C$	50 - 400	47 - 375	3.5	Si array	Fluorine puzzle
$^{23}Na(p,\gamma)^{24}Mg$	139; 290 - 400	133; 277-383	5	BGO	GC anomalies
$^{10}B(p,\alpha)^{7}Be$	50-400	45-364	1	HPGe	pre-, main sequence
$^{10}B(p,\gamma)^{11}C$	55-240	50-220	2	HPGe	pre-, main sequence
	55-240	50-220	1	BGO	pre-, main sequence
$^{11}B(p,\alpha)^{8}Be$	50-400	46-367	1	Si array	pre-, main sequence
$^{11}B(p,\gamma)^{12}C$	65-400	60-360	2	HPGe	pre-, main sequence
Total Time			15.5		

Riunione Preventivi Gr3

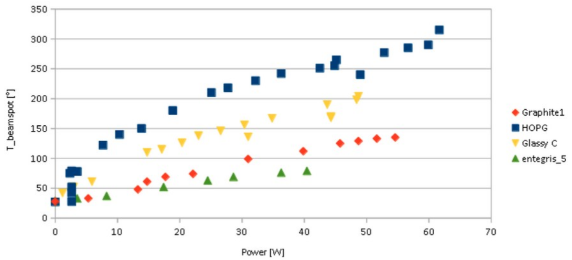
PRINCIPALI ATTIVITÀ LUNA-PD 2025-2026 AT IBF BELLOTTI

12C+12C reaction study

The fusion of 12C isotopes is fundamental to understanding the carbon burning, which determines the minimum masses for core collapse supernova

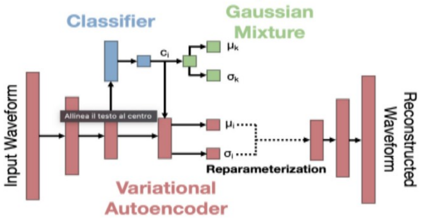


The new HPGe for low counting activity has been characterised and the results have been published in J. Phys G (Gesué, Turkat et al.)

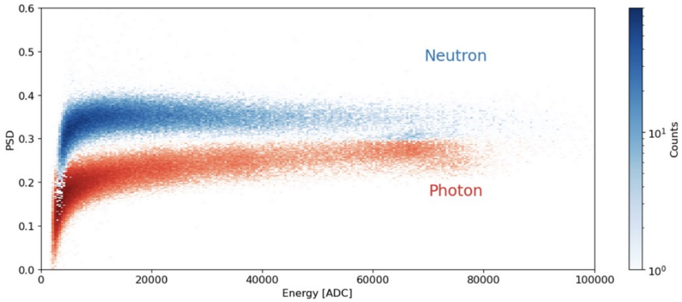


Targets have been tested at the Felsenkeller facility (beam time financed by CHETEC-INFRA. **D. Piatti** was coordinating.

22Ne(alpha,n)25Mg



This reaction is producing all the neutron for the weak s-process. No data available in literature below 800 keV due to background. A new detector called SHADES (ERC project) has been designed for this study and **Dr. Skowronski** developed a neural network to enhance the gamma-neutron discrimination. Results accepted to J. Phys. G



LUNA

ADDITIONAL ACTIVITIES IN LUNA AND OTHER FACILITIES

22Ne(alpha,gamma)26Mg reaction study

In 2026, the study of the gamma channel that competes with the (alpha,n) reaction for the destruction of 22Ne in the AGB, reducing the number of neutrons available for s-process, is planned. A new NaI array has been purchased with external funds (EASY project). The Padova group is responsible for the operation and construction of the DAQ

Characterization of Implanted and Sputtered 3He targets on Gold

The 3He targets used for the lifetime measurement of the 15O excited states with AGATA (2023) has been thourghly characterized at CNA (Sevilla) and HZDR (Dresden) laboratories. The results has been published in EPJA 61, 117 (2025) (Skowronski Corr Author)

Experiments at Felsenkeller

Our activity on ancillary experiment at the shallow underground laboratory of Felsenkeller is ongoing also this year with some experiment with Caciolli and Piatti as spokespersons

INFN

RICHIESTE FINANZIARIE LUNA3 @ PD PER 2026

- Missioni: 32 k€ turni LNGS, 3 k€ misure a LNL. Totale 35 k€
- Richiesta di 10 k€ per acquisto target prodotti con fluorizzazione

0.5 mese uomo elettronica -> supporto per DAQ e test su FPGA CAEN CARD
0.5 mese uomo progettazione -> holder per nuova camera di scattering con riv. silicio
1 mesi uomo officina meccanica -> esecuzione lavori progettazione

FONDI ESTERNI LEGATI AD ATTIVITÀ LUNA

- CHETEC-INFRA: 85k€ at UNIPD (local coordinator A. Caciolli)
- PRIN2020: 65k€ at UNIPD (local coordinator A. Caciolli)
- Progetto Terza Missione 2023: 50k€ (coordinator A. Caciolli)

PANDORA
A.Pepato

PANDORA
updates 04/2025

Plasmas for
Astrophysics
Nuclear
Decay
Observation and
Radiation for
Archaeometry

David Mascali and Domenico Santonocito (LNS-INFN)
on behalf of the PANDORA collaboration

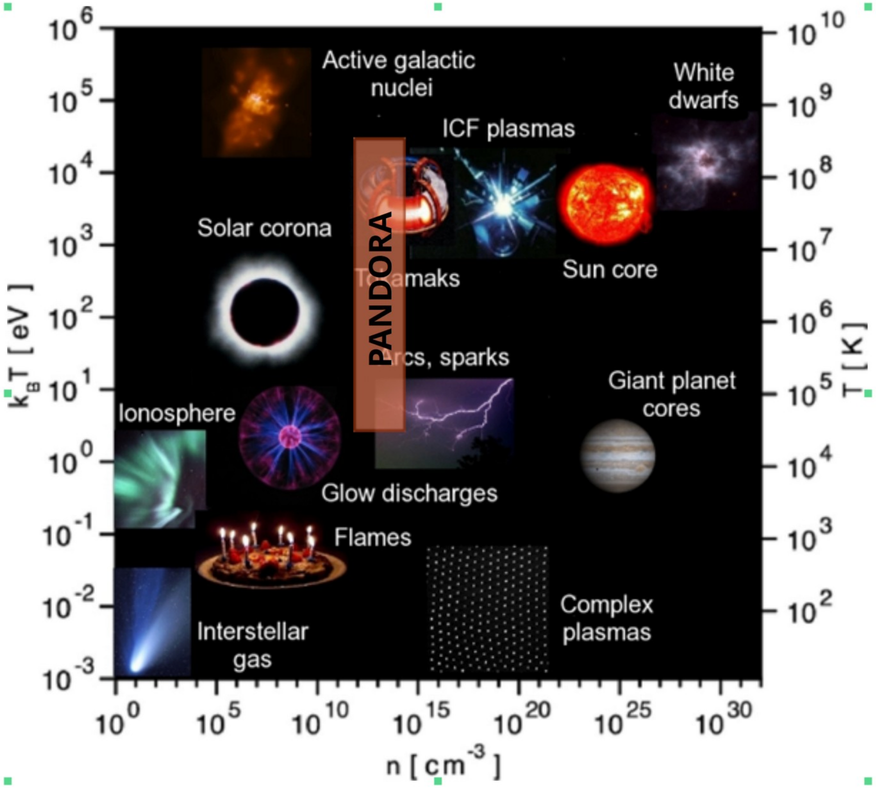
INFN LNS
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Sud

PANDORA main goal: Investigating β-radioactivity in a «stellar» environment

Plasmas can be created in different thermodynamical conditions

Different approaches allow to investigate different regions of (T, ρ)

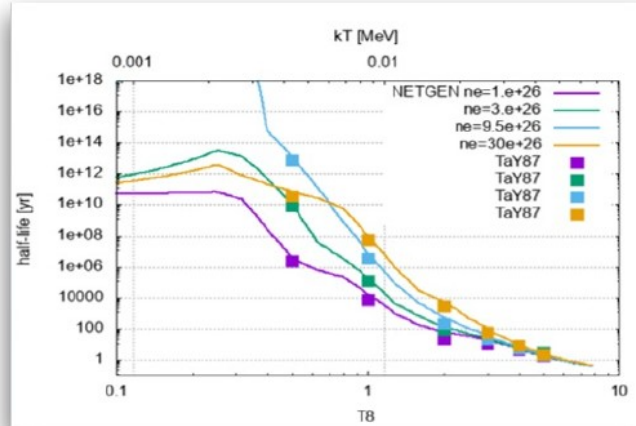
In plasma beta decay studies allows to investigate the effects of the ''environment'' on nuclear properties and reaction mechanisms



PANDORA main goal: *Investigating β-radioactivity in a «stellar» environment*

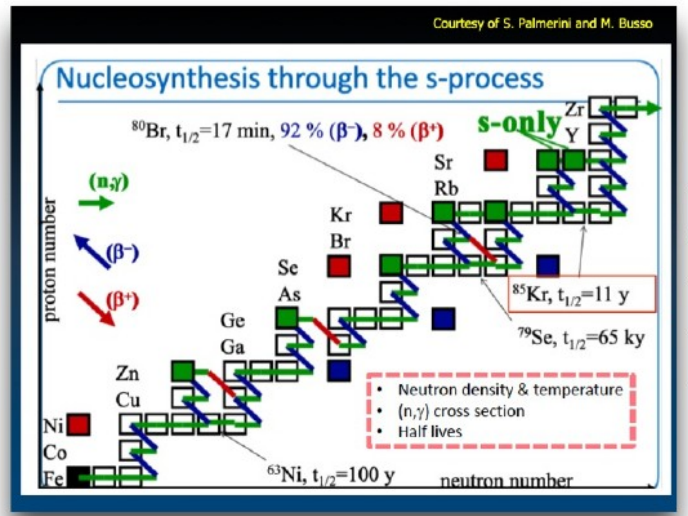
Make β-decay measurements in plasmas of astrophysical interest: many isotopes can change their lifetime of several order of magnitude when ionized!!

The effect is mainly driven by the opening of a new decay channel: the bound state beta decay



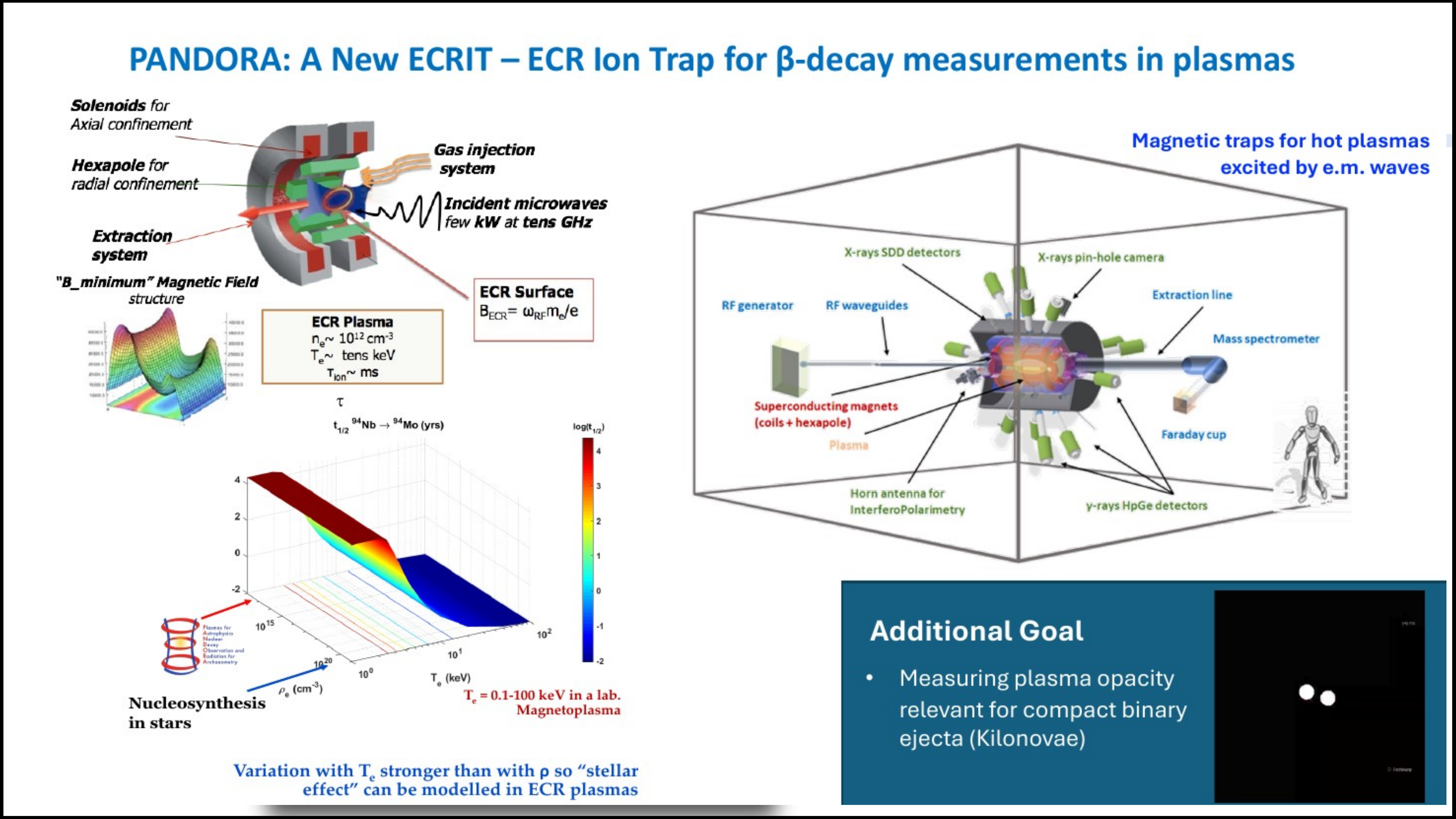
Takahashi et al. 1987, Phys Rev C 36, 1522.

Direct implication on branching points in s-process nucleosynthesys chain competition of neutron capture vs β-decay



Isotope	$T_{1/2}$ (yr)	Eγ (keV)	
^{176}Lu	3.78×10^{10}	88-400	COSMO-CHRONOMETER
^{134}Cs	2.06	>600	reproduction of ^{134}Ba, ^{136}Ba s-only isotope yields
^{94}Nb	2.03×10^{4}	>700	

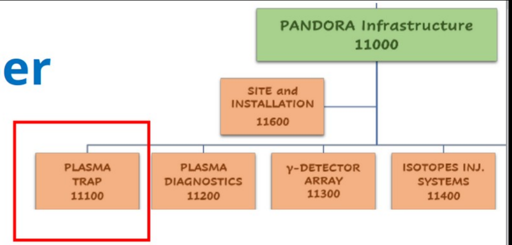
Solving the puzzle about the contribution of s-processing to ^{94}Mo: β-decay or binary stars


PANDORA: A New ECRIT – ECR Ion Trap for β-decay measurements in plasmas
Solenoids for Axial confinement
Hexapole for radial confinement
Gas injection system
Incident microwaves few kW at tens GHz
Extraction system
"B_minimum" Magnetic Field structure
ECR Surface
$B_{ECR} = \omega_{RF} m_e / e$
ECR Plasma
$n_e \sim 10^{12}$ cm^{-3}
$T_e \sim$ tens keV
$\tau_{ion} \sim$ ms
$t_{1/2}$ ^{94}Nb → ^{94}Mo (yrs)
log($t_{1/2}$)
ρ_e (cm^{-3})
T_e (keV)
T_e = 0.1-100 keV in a lab. Magnetoplasma
Nucleosynthesis in stars
Variation with T_e stronger than with ρ so "stellar effect" can be modelled in ECR plasmas
Magnetic traps for hot plasmas excited by e.m. waves
X-rays SDD detectors
X-rays pin-hole camera
RF generator
RF waveguides
Extraction line
Mass spectrometer
Superconducting magnets (coils + hexapole)
Plasma
Faraday cup
Horn antenna for InterferoPolarimetry
γ-rays HpGe detectors
Additional Goal
• Measuring plasma opacity relevant for compact binary ejecta (Kilonovae)

PANDORA
A.Pepato

MAIN SUBSYSTEMS UPDATES: plasma chamber

(LNS + PD ACTIVITY)



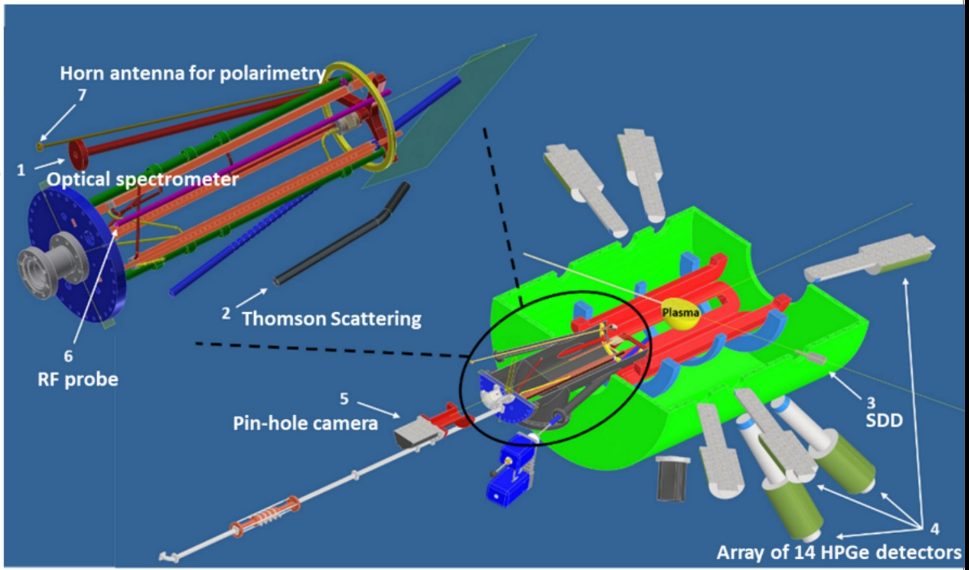
The design of the main plasma chamber is ongoing

The end caps, through several flanges and feedthroughs, allow to connect the vacuum pipe, the RF injection waveguides, the gas inlet, the oven, and several diagnostic devices.

Many aspects concerning the positioning of different diagnostic tools on the injection side of the chamber were defined but still work needs to be done to complete the design.

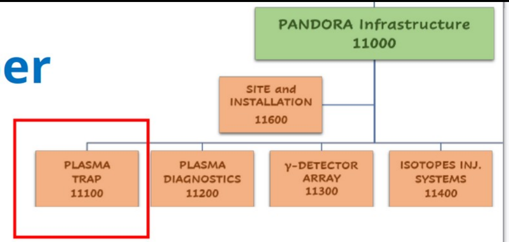
The completion of the design will be possible only when the technical specifications (dimensions) of the magnetic trap will be known.

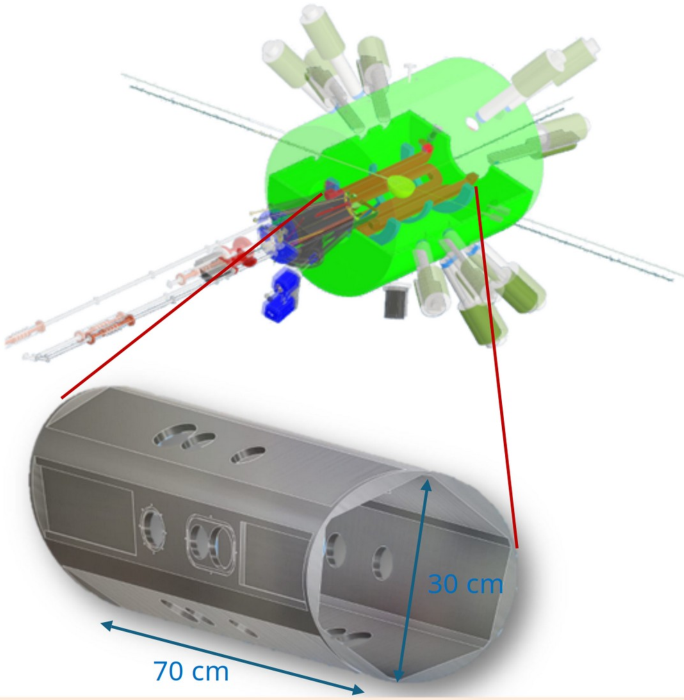
With INFN-PD we have already ordered 120 kg of Inconel (Nickel alloy) for the chamber fabrication by Additive Manufacturing

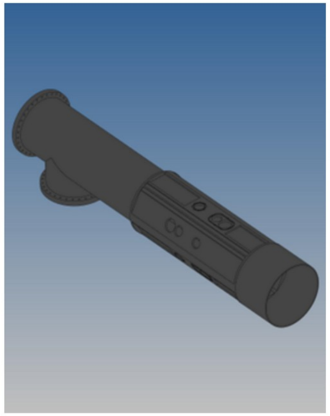


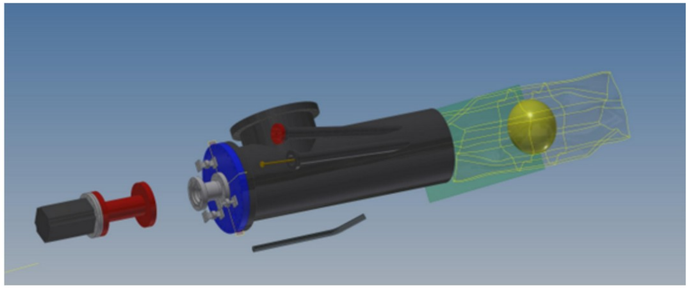
MAIN SUBSYSTEMS UPDATES: plasma chamber

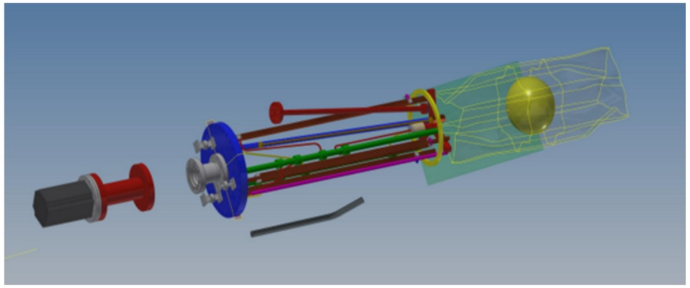
(LNS + PD ACTIVITY)











An advanced (Stain. Steel) plasma chamber design is needed to operate at 10^{-8} mbar supporting a 10 kW plasma power and radial "holes" for measuring γ-ray emission

Vacumm: 10^{-8}-10^{-7} mbar
Total RF power: 10 kW

SPES-MED
S.Moretto

6 Applications

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Padova Personnel and Project Participation

WP2: Isol production yield measurements
WP3: Nuclear modeling and Monte Carlo simulations

NAME	WP
Sandra Moretto	2
Marcello Lunardon	2
Daiyuan Chen	2,3
Francesca Barbaro	3
Luciano Canton	3
Laura DeNardo	3
Yulia Lashko	3
Lisa Zangrando	3

2.80 fte

WP3 Leaders: Francesca Barbaro, Lisa Zangrando

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WP2:STATUS AND IMPROVMENTS

	WP2 - ISOL yield measurements												
MS2.1	Report on testing and refinement of IRIS and tape system	→			●								
MS2.2	Report on ISOL transport and ionization efficiencies measured with stable beams	→			●								
MS2.3	Report on resonant laser studies of Mg photo-ionization schemes	→							●				
MS2.4	Report on yield measurements of Mg-28 and optimization of SiC targets					→			●				
MS2.5	Report on resonant laser studies of Cr and Ag photo-ionization schemes					→							●
MS2.6	Report on yield measurements of K-43 (and possibly Cr-51 and Ag-111) and optimization of TiC targets									→			●

MS2.1 50%

Tape system: done. IRIS: work in progress. Report from D. Chen's PhD thesis or papers*.

MS2.4 10%

Giulia Persi BSc thesis (supervisors: S. Moretto, A. Leso) will develop an online spectral analysis tool on the ISOLPHARM website with the help of L. Zangrando.

*D. Chen, S. Corradetti, D. Serafini, A. Leso, M. G. Martello, A. Arzenton, M. Ballan, A. Donzella, A. Monetti, M. Lunardon, E. Mariotti, A. Andrighetto. *SPES low-energy beamline status and development of ISOLPHARM Radionuclide Implantation Station (IRIS)*, NIMA, under review.
*A. Arzenton, D. Chen, M. Lunardon, S. Moretto, G. S. Valli, A. Andrighetto, S. Corradetti, A. Leso, M. G. Martello, D. Serafini, E. Mariotti. *The SPES-ISOLPHARM beamline for the production of medical radionuclides at INFN-LNL*, HIAT Conference Proceedings, under review.

WP3: STATUS AND IMPROVEMENTS

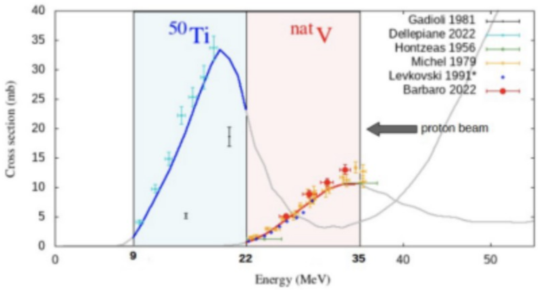
	WP3 - Models and simulations	Year 1				Year 2				Year 3			
MS3.1	Report on cross-section, yields and purity modelling for Sc-47 production	→			•								
MS3.2	Report on cross-section, yields and purity modelling for Tb radioisotopes					→			•				
MS3.3	Report on cross-section, yield and purity modelling for Cu-67 (and possibly other theranostic nuclides)									→			•

→ ^{47}Sc

~80% completed

PAPERS:

- ***Bilayer target** for efficient production of ^{47}Sc from proton-induced irradiation*, L Canton, F Barbaro, Y Lashko, L De Dominicis, L Mou, G Pupillo, Applied Radiation and Isotopes – **ACCEPTED**
- ***Bilayer-Target** Strategy for Efficient Proton-Induced ^{47}Sc Production*, L Canton, F Barbaro, Y Lashko, L De Dominicis, L Mou, G Pupillo, The European Physical Journal Plus - **UNDER REVIEW**
- *^{47}Sc production for medical applications: cross-section optimization with genetic algorithms*, Y Lashko, L Canton, L Zangrando, F Barbaro, Journal of Physics G: Nuclear and Particle Physics - **UNDER REVIEW**



TALK & POSTER:

- *Smart Tuning of ^{47}Sc Production: Genetic Algorithms Meet Nuclear Data*, F Barbaro, L Canton, Y Lashko, L Zangrando, Workshop sul Calcolo nell'INFN, La Biodola, 26th-30th May 2025
- *Optimizing Nuclear Cross-Section Data for ^{47}Sc Production Using Genetic Algorithms,* L Canton, F Barbaro, Y Lashko, L Zangrando, ND2025, Madrid, 22nd 27th June 2025
- *Assessing the Viability of $^{49}Ti(p,x)^{47}Sc$ for Medical Applications: A Genetic Algorithm Approach,* Y Lashko, F Barbaro, L Canton, L Zangrando, IWNT42-2025, Rila, 29th June-5th July 2025

- **M3.4: Simulations of magnesium-28 release from the target are currently in progress.**
  - At this stage, they are running locally, to validate the correct implementation of silicon carbide (SiC) disks in the model.
  - The work is being carried out by Sara Luise, a BSc Physics student, under the supervision of Sandra Moretto and Alberto Arzenton.
- **M3.5: Calculations for laser photo-ionization are also ongoing.**
  - A previous study on silver conducted by the laser group is currently under review.
  - Similar studies on gallium and scandium will soon be performed by another BSc student, Roberto Gazzola, also supervised by Sandra Moretto and Alberto Arzenton.

2026 QUOTES AND REQUESTS @SPES-MED PADOVA

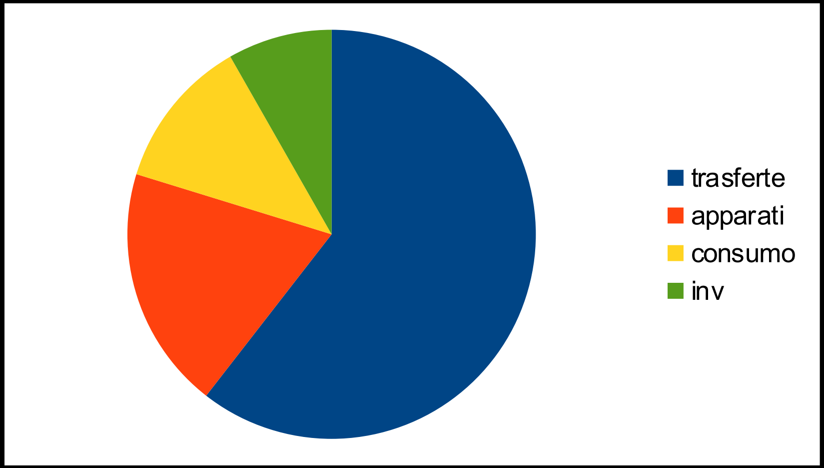
No requests for mechanical and electronic workshops

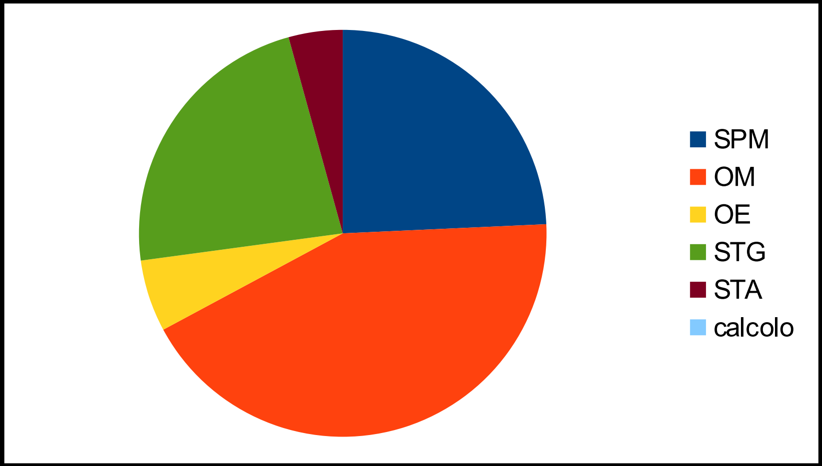
	REQUEST	MOTIVATION
CONSUMABLES	2 keuro	**IRIS IMPLEMENTATION:** For the implementation, within the IRIS system, of a protocol for gamma spectroscopy, the purchase of various components is requested (currently in the phase of quotation) The characteristics of the setup will also be transferred as general-purpose instrumentation to other ISOL facilities.
TRAVELS	4 kEuro	**Travel** for experimental/collaboration activities and specific training courses

FONDI

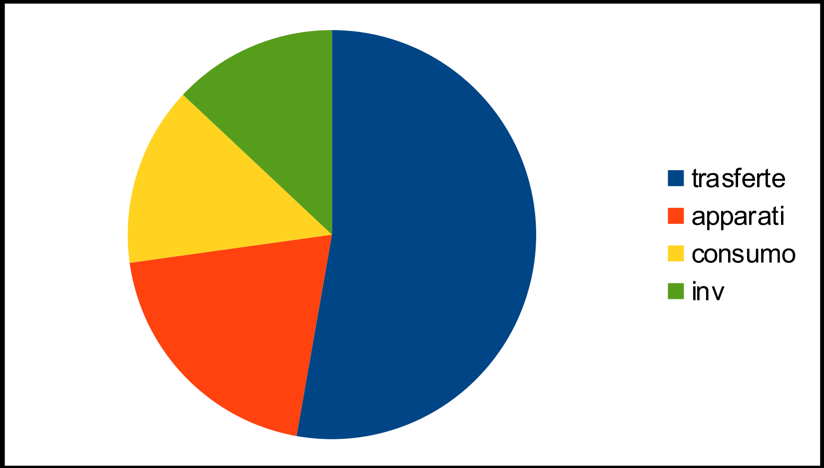
SERVIZI

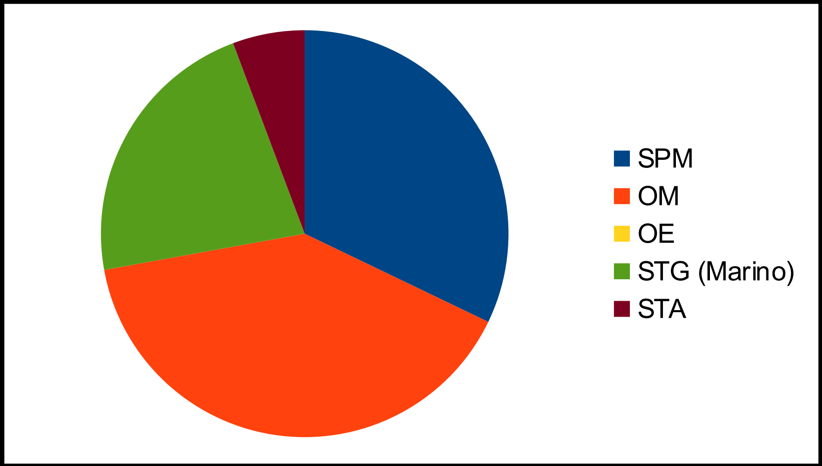
2024





2025





Sommario preliminare

	>= PhD										
2025	pp	FTE	trasferte	apparati	consumo	inv	SPM	OM	OE	STG (Marino)	STA
ALICE	18.00	14.80	113.50		8.00	35.00	2.00	2.00		6.00	
NA60+	2.00	0.20	3.00								
EIC/ePIC	9.00	2.50	10.00	15.00	27.00	1.50	9.00	5.00		1.00	4.00
ASFIN2	5.00	4.10	23.50	25.00	2.00	5.00	1.00	2.00		2.00	
GAMMA	19.00	16.70	100.00	70.00	30.00		10.00	18.00		6.00	5.00
R4I_BETASmart	3.00	1.40			5.00	35.00	1.00	0.50		0.50	1.00
LUNA3	6.00	4.30	32.00		10.00	30.00	0.50	1.00		0.50	
PANDORA	4.00	1.00	4.00								
SPES_MED	8.00	2.80	4.00		1.00						
tot	74.00	47.80	290.00	110.00	83.00	106.50	23.50	28.50	0.00	16.00	10.00
Δ	12.00	6.75	22.50	25.00	30.00	70.00	6.50	-1.50	-4.00	0.00	7.00

SIGLE DA CONFERMARE

R4I in fase di valutazione

Grazie per l’attenzione